# OMEGA®
# ENGINEERING, INC.

## OWNERS MANUAL

# MODEL 400A

## OMEGA'S DIGITAL TEMPERATURE INDICATORS

## WARRANTY

**OMEGA** warrants this unit to be free of defects in materials and workmanship and to give satisfactory service for a period of 1 year. If the unit should malfunction, it must be returned to the factory for evaluation. Our Customer Service Department will issue an Authorized Return Number immediately upon phone or written request. Upon examination by **OMEGA,** if the unit is found to be defective, it will be repaired or replaced at no charge. However, this WARRANTY is VOID if the unit shows evidence of having been opened or tampered with, shows evidence of being damaged as a result of excessive current, heat, moisture, vibration or misuse. **OMEGA** assumes no consequential warranties or obligations beyond repair or replacement of the above unit.

## OMEGA ENGINEERING INC.


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Printed in U.S.A.
**Manual 400-4203-00**



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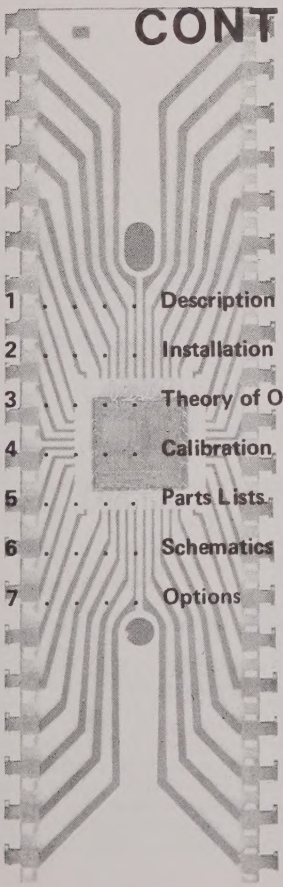


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# SECTION 1

# DESCRIPTION

## 1.1 GENERAL DESCRIPTION

This manual contains installation, operation and service information for Series 400A Trendicators. These solid state instruments digitally display a number of thermocouple, RTD, linear voltage sources and current transmitter outputs in engineering units. Trendicators feature a microvolt A to D converter, digital linearization, dual slope integration, and a large easy-to-read LED display.

The displays are in-line, uniplanar, LED type, 0.63 inch high red numerals, easily read through the front plexiglas panel. A single "–" display at the left of the readout indicates a negative polarity. No symbol is displayed for positive readings. All dashes (––––) across the display indicate an overload, overrange or open thermocouple condition. Zeros to the left of the decimal point or most significant digit are suppressed.

Trendicators may be readily converted to accept all ranges shown in Paragraph 1.1.1 by installing the appropriate PMOS LSI chip and the proper analog program module. Two LSI chips, K7500 or K7501, handle all ranges listed, but an individual programming module must be used for each range specified. Units (except THF-THC) are easily converted from °F to °C (and vice versa) by a switch located behind the front panel.

The instruments are ordered with either high or low sensitivity (resolution). Instruments with thermocouple input ranges provide resolution of 1°F or 1°C in the standard TC system with 0.1°F or 0.1°C available where higher sensitivity is required. Transmitter input ranges are available with 0.1% or 0.01% resolution. Resolutions for linear voltage inputs are shown in paragraph 1.1.1.

All units operate from a 115 or 230 VAC (+10%, –15%) power source, 48 to 400 Hz (see paragraph 2.3.1.2). Units powered by the optional battery power pack operate on an internal 10 VDC source. Power consumption is about 1.5 watts under typical operation, or about 4 watts with all segments lit. A power connector and ground screw for shields are located at the rear of the instrument.

Each unit is delivered with panel mounting hardware as standard equipment. Rack and bench top mounting hardware are optionally available to accommodate those modes of installation. Battery-powered units are provided with a carrying case.

## 1.1.1 INPUT RANGES AND RESOLUTION

Installing the correct Range Module (Col. 1) and LSI chip (Col. 3) converts model ranges as shown in the following chart.

| RANGE DESIGNATOR | RANGE | IC TYPE | INPUT SENSOR TYPE | RESOLUTION MODEL 40X | RESOLUTION MODEL 41X |
|---|---|---|---|---|---|
| J (NBS) | -328 to +1712°F<br>-200 to +933°C | K7500 | Iron Constantan* | 1° | 0.1° |
| K (NBS) | -208 to +2552°F<br>-133 to +1400°C | K7500 or K7501 | Chromel-Alumel* | 1° | 0.1° |
| T (NBS) | -328 to +752°F<br>-200 to +400°C | K7500 | Copper-Constantan* | 1° | 0.1° |
| R (NBS) | +32 to +3252°F<br>0 to +1788°C | K7500 | Platinum-Platinum* 13% Rhodium | 1° | 0.1° |
| S (NBS) | +32 to +3252°F<br>0 to +1788°C | K7500 | Platinum-Platinum* 10% Rhodium | 1° | 0.1° |
| B (NBS) | 912 to +3392°F<br>489 to +1866°C | K7500 | Plat. 30% Rhod./* Plat. 6% Rhod. | 1° | 0.1° |
| FeCon (DIN) | -327.9 to +1651.9°F<br>-199.9 to +899.9 C | K7501 | Iron-Constantan* | 1° | 0.1° |
| CuCon (DIN) | -327.9 to +1111.9°F<br>-199.9 to +599.9°C | K7501 | Copper-Constantan* | 1° | 0.1° |
| E (NBS) | -327.9 to +1951.9°F<br>-199.9 to +1066.6°C | K7501 | Chromel-Constantan* | 1° | 0.1° |
| PT3 & PT4 (DIN) | -387.9 to +1631.9°F<br>-233.3 to +888.8°C | K7501 | 3 or 4-wire RTD<br>0.00385 $\alpha$ | 1° | 0.1° |
| CU3 & CU4 | -75.0 to +400°F<br>-60.0 to +200.0°C | K7501 | 2 or 4-wire (CU4)<br>3-wire (CU3) RTD | 1° | 0.1° |
| THF<br>THC | 32.0 to 212.0°F<br>0.0 to 100.0°C | K7501 | THERMISTOR | 0.1° | 0.01° |
| K1 | -10 to +25 mV | K7501 | Linear Voltage | 10$\mu$V | 1$\mu$V |
| K2 | -100 to +250 mV | K7501 | Linear Voltage | 100$\mu$V | 10$\mu$V |
| K3 | -1 to +2.5 V | K7501 | Linear Voltage | 1 mV | 100$\mu$V |
| K4 | -10 to +25 V | K7501 | Linear Voltage | 10mV | 1 mV |
| I1 | 0 to 100% | K7501 | 4 to 20 mA Current Transmitter | 0.1% | 0.01% |
| I2 | 0 to 100% | K7501 | 10 to 50 mA Current Transmitter | 0.1% | 0.01% |
| $I_3$ | +100 to +2500 digits (Models 400A, 402A); +1000 to +25000 digits (Models 410A, 412A) | K7501 | 4 to 20 mA Current Transmitter | 0.001 | 0.0001 |
| 1000 mV† | -0.5 V to +1 V | K7501 | Linear Voltage | 1mV | 100$\mu$V |

* Thermocouple Type Sensor

† Available in Models 408 and 418 only.

## 1.2 DESCRIPTION OF THE MODELS

The following table lists Trendicators by model, and shows the range and number of input points accepted by each.

| MODEL → | 400A | 402A | 403A | 405A | 406 | 407 | 408A | 409A | 410A | 412A | 415A | 418A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NO. POINTS → | 1 | 5 | 1 | 10 | 1 | 1 | 1 | 10 | 1 | 5 | 1 | 1 |
| MULTIRANGE → | NO | NO | YES | NO | NO | NO | YES | NO | NO | NO | YES | YES |
| RANGE ↓ | | | | | | | | | | | | |
| J | X | X | X | X | X | X | | | X | X | X | |
| K | X | X | X | X | X | X | X | | X | X | X | X |
| T | X | X | X | X | X | X | | | X | X | X | |
| R | X | X | X | X | X | X | | | X | X | X | |
| S | X | X | X | X | X | X | | | X | X | X | |
| B | X | X | X | X | X | X | | | X | X | X | |
| FeCon | X | X | | X | X | X | X | | X | X | | X |
| CuCon | X | X | | X | X | X | X | | X | X | | X |
| E | X | X | | X | X | X | X | | X | X | | X |
| PT3 & PT4 | X | | | | X | | X | X | X | | | X |
| CU3 & CU4 | X | | | X[3] | X | | | X | X | | | |
| THC & THF | X | | | | X | | | X | X | | | |
| K1 – K4 | X | X | | X | X | X[4] | | | X | X | | |
| 1000 mV | | | | | | | X | | | | | X |
| I1 – I3 | X | | | | X | | | | X | | | |

Note 1: Models 408A and 418A available in °C only.
Note 2: Models 406 and 407 must be used with Models 400A or 410A.
Note 3: Model 405A may be used with CU4 when CU4 is connected 2-wire.
Note 4: Model 407 can be used for K1 range only.

### 1.2.1 SINGLE RANGE MODELS

Models 400A, 402A, 410A and 412A are all single range instruments which can be adapted to accept any range (PT, CU, TH and I ranges excepted on Models 402A/412A). Two of these single range models, the 402A and 412A, have push-buttons to select any 1 of 5 points within a chosen range. Models 400A and 402A have standard resolutions, while Models 410A and 412A have higher sensitivity (see paragraph 1.1.1). Optional battery pack (see Models 406 and 407) is available for Models 400A and 410A.

### 1.2.2 MULTI-RANGE MODELS

Models 403A, 408A, 415A, and 418A have pushbutton-selectable ranges. Models 403A and 408A resolve readings to 1°; Models 415A and 418A resolve 0.1°. Models 403A and 415A accept J, K, T, R, S, and B thermocouple inputs; Models 408A and 418A accept FeCon, CuCon and E thermocouples inputs, PT4 input, and 1000 mV linear input (For correct 1000 mV range readings the °F/°C switch must be set to °C).

### 1.2.3 THE SWITCHING UNITS (MODELS 405A AND 409A)

These 10-point pushbutton switchers make any single-range Trendicator a multipoint indicator. Each may be rack-mounted beside another switcher or a Trendicator. Pushbuttons are in two rows of five and are numbered 1-10, 11-20, etc. Each row is interlocked to prevent simultaneous input selection. Option 001A may be used with one or more switchers, and blanks the display if simultaneous selections are made from two rows. The Model 405A may be used for thermocouple ranges, K ranges, the 1000 mV range, and for 2-wire operation on the CU4 range. The Model 409A must be used for PT, CU, and TH ranges.

### 1.2.4 THE POWER PACKS (OPTIONS 406 AND 407)

Options 406 and 407 are batterypack/chargers with low-battery LED indicators. The 407, in conjunction with its Trendicator, is also a precision calibrator.

A Trendicator/Power pack is housed in a carrying case, as shown in Figure 2-6, with interconnection made at the rear (see Figure 2-7). The Model 406 may have either 2 or 4 input terminals, the latter for PT, CU, and TH ranges. The Model 407 always has 2 input terminals and is used for thermocouple and K1 ranges only.

With the power pack connected to the AC line and power switch OFF, the batteries charge and the Trendicator operates from AC. With the power pack switch ON the Trendicator operates from batteries.

The Model 407, in addition to its power switch, has 2 calibrator controls: One is a 10-turn COARSE adjustment, the other an ON-OFF/FINE adjustment. The latter turns the calibration output ON, and after the COARSE adjustment is made, provides a vernier range of approximately ±20 μV with 1 μV or 0.1° resolution.

With the power switch ON and the FINE control OFF the Trendicator may be used for measurements; with the FINE control ON the calibrator output is displayed on the Trendicator and available at the terminals.

## 1.3 PHYSICAL DESCRIPTION

All Series 400A instrument cases are constructed of die cast aluminum covered with textured vinyl paint. Case dimensions are 72mm x 144mm x 173mm (2.84

x 5.67 x 6.82 inches). The case inserts into a panel cut-out of 68mm x 138mm (2.68 x 5.44 inches). These dimensions are shown on outline dimensional drawing 000-7840-00 in the rear of this manual. Net instrument weight is about 1.7 Kg (2½ lbs.).

When installed into the portable housing with the battery unit, the external case dimensions are 144mm x 144mm x 200mm (5.67 x 5.67 x 7.78 inches). Weight of the portable battery unit is 4.8 Kg (10½ pounds).

## 1.4 WARRANTY REPAIR

This unit is warranted to be free of defective materials or workmanship and to give satisfactory service for one year. If the unit malfunctions, return it to the factory for evaluation. Our Customer Service Department will issue an Authorized Return Number upon phone or written request. If evaluation shows the instrument to be defective it will be repaired or replaced at no charge.

This WARRANTY is VOID if the unit shows evidence of having been opened or tampered with or shows evidence of damage due to excessive current or voltage, heat, moisture, vibration or misuse.

In any event no warranties or obligations beyond replacement or repair of the unit will be assumed.

## 1.5 SPECIFICATIONS

Ambient Operating Temperatures:
0 to 50°C; 32 to 122°F

Ambient Humidity:
0 to 70% at 0 to 50°C for rated accuracy.

Power:
100 to 125 VAC, 48 to 400 Hz, or, 190 to 250 VAC, 48 to 400 Hz

Normal Mode Noise Rejection:
56 db at 50 Hz
60 db at 58 Hz and above
(3 pole, low-pass filter with 6 Hz poles; 1 pole on K3, K4)

Common Mode Noise Rejection:
110 db at 50 Hz; 120 db at 58 to 62 Hz (250Ω unbalance)
(up to 230 VDC or VAC RMS)

RFI Suppression:
Power line and sensor RFI filtering included

Reliability:
30,000 hours MTBF, calculated and demonstrated

Input:
Bipolar potentiometric operational amplifier with an input impedance at room temperature of:
22 megohms for thermocouple ranges

71 KΩ for PT, CU and TH ranges.
12.5 ohms for I1 transducer ranges (4-20 mA)
5 ohms for I2 transducer ranges (10-50 mA)
6 ohms for $I_3$ transducer ranges (4-20 mA)
1,000 megohms for K1, K2, K3 ranges
10 megohms for K4 range

Open T/C or Break Detection:
On TC ranges, 30 nanoamp, negative DC. Allows parallel connection of most other controllers with negligible interaction. RTD ranges inherently upscale break detect.

Source Resistance Effect:
TC ranges: 1.5 μV offset/50Ω.
PT4 range: 0.03° C/Ω offset in +I and -V leads; 0.001° C/Ω in +V and -I leads.
PT3 range: add 2.5° C/Ω unbalance between +I, +V, and -V leads.
CU4 range: 0.02° C/Ω offset in +I -V leads and 0.002° C/Ω in +V and -I leads.
CU3 range: add 25.9° C/Ω unbalance between +I, +V and -V leads.

Overload Protection:
TC, linear voltage, RTD and TH ranges: 120vAC or DC continuous. 230vAC or DC for 5 minutes without damage.
I1 range: up to 80 mA
I2 range: up to 200 mA
$I_3$ range: up to 80 mA

Measurement Time:
0.3 second per reading at low magnitudes
Up to 1.5 seconds per reading at upper limit magnitudes

Battery type (Option 406):
10V, rechargeable, sealed module.
4-8 hours continuous operation per charge. Recharge time of 5-8 hours.
Good for 500 cycles.

Linearization:
100% digital using segments as shown for range:

| Range | Segments |
|---|---|
| J, K, R, S, B, PT-100 | 46 |
| Fe Con, Cu Con | 45 |
| E | 44 |
| T | 42 |

Linearization is built into each PMOS LSI chip.

Segment sizes for Linearization:

| Range | Segment (°F) |
|---|---|
| R, S | 70° |
| B | 80° |
| K | 60° |
| J | 60° > 32°F<br>20° < 32°F |
| T | 30° > 32°F<br>20° < 32°F |
| PT-100 | 30° < 32°F < 50° |
| Fe Con | 20° < 32°F < 60° |
| Cu Con | 40° < 32°F < 30° |
| E | 30° < 32°F < 60° |

Stability with temperature:

Cold junction: (TC ranges only)

0.025 degrees/degree from 10 to 40°C (50 to 104°F) for base metal types; 0.05 degrees/degree for noble metals

Instrument zero:

1 μV/°C for Models 400A and 402A except 2 μV/°C on $I_3$ range

0.5 μV/°C for Models 410A and 412A except 1.5 μV/°C on $I_3$ range

Instrument span:

0.01% RDG/°C for Models 400A and 402A except 0.02% RDG/°C on $I_3$ range

0.005% RDG/°C for Models 410A and 412A except 0.015% RDG/°C on $I_3$ range

Stability with time:

Instrument zero:

No measurable zero drift

Instrument span:

0.1% of RDG/yr for transmitter and voltage ranges; less than 1°/yr for TC, RTD, and TH ranges.

Repeatability:

±1 digit except on listed 410A, 412A, 415A ranges:

±2 μV on K1, CU and TH ranges,

±0.2°C or F on R, S, and B ranges,

±0.2°F below -200°F on T range.

## Accuracy

| RANGE DESIGNATOR | TYPE OF INPUT | RANGE | ACCURACY (all ±) includes max. linearization error. 400A/402A 403A/408A | ACCURACY (all ±) includes max. linearization error. 410A/412A 415A/418A |
|---|---|---|---|---|
| J | Iron-Constantan Thermocouple | -328°F to +1712°F<br>-200°C to +933°C | 1°<br>1° | 0.6°F<br>0.5°C |
| K | Chromel-Alumel Thermocouple | -208°F to +2552°F<br>-133°C to +1400°C | 1.5° < 0° < 1°<br>1° | 1.2° < 0° < 0.8°<br>0.8° < 0° < 0.5° |
| T | Copper-Constantan Thermocouple | -328°F to +752°F<br>-200°C to +400°C | 1°<br>1° | 0.5°F<br>0.5°C |
| R | Platinum-Platinum 13% Rhodium Thermocouple | +32 to +3252°F<br>0 to +1788°C | 3° < 350°F < 2°<br>2° | 3° < 350°F < 1.5°<br>2° < 200°C < 1°<br>0.6° above 800°C |
| S | Platinum-Platinum 10% Rhodium Thermocouple | +32 to +3252°F<br>0 to +1788°C | 3° < 600°F < 2°<br>2° | 2° < 600°F < 1.5°<br>2° < 315°C < 1°<br>0.5° above 800°C |
| B** | Plat 30% Rhod/ Plat. 6% Rhod Thermocouple | +912 to +3392°F<br>+489 to +1866°C | 4°<br>2.5° | 2.5°<br>1° |
| FeCon | DIN Thermocouple Iron-Constantan | -200°C to +900°C | 1° | 0.4° |
| CuCon | DIN Thermocouple Copper-Constantan | -200°C to +600°C | 1° | 0.4° < 0°C < 0.2° |
| E | E(NBS) Thermo-couple Chromel-Constantan | -328°F to +1952°F<br>-200°C to +1066°C | 1°<br>1° | 0.7°<br>0.4° |
| PT3 & PT4 | PT-100 RTD | -388 to +1632°F<br>-233 to +888°C | 1°<br>1° | 0.7° < -328° < 0.4°<br>0.3° < -200° < 0.2° |
| CU3 & CU4 | CU-10 RTD | -75 to +400°F<br>-60 to +200°C | 1°<br>1° | 1.0°<br>1.0° |
| THF & THC | YSI Thermistor Series 700 | +32 to +212°F<br>0 to +100 C | 0.4°<br>0.2° | 0.40°<br>0.20° |
| $I1$* | 4-20 mA Transducer Current Transmitter | 0 to 100% | 1 count | 0.01% of reading<br>±1 count |
| $I2$* | 10-50 mA Transducer Current Transmitter | 0 to 100% | 1 count | 0.01% of reading<br>±1 count |
| $I3$ | 4-20 mA Transducer Current Transmitter | Span Digits Adj. (20 mA input): +1000 to +2500, 400A and 402A, +10000 to 25000, 410A and 412A. Offset Digits Adj. (4 mA input): ±5 times span to max. of -1000 +2000 for 400A and 402A; ±5 times span to max. of -10000 +20000 for 410A and 412A | 2 counts | 0.02% of reading and 1 count |
| K1* | 25 Millivolt Range Linear Voltage | -10 mV to +25 mV | 1 count | 0.01% of reading ±2 counts |
| K2* | 250 Millivolt Range Linear Voltage | -100 mV to +250 mV | 1 count | 0.01% of reading ±1 count |
| K3* | 2.5 Volt Range Linear Voltage | -1V to 2.5V | 1 count | 0.01% of reading ±1 count |
| K4* | 25 Volt Range Linear Voltage | -10V to 25V | 1 count | 0.01% of reading ±1 count |

Resolution for Thermocouple and PT-100 models; 400A/402A/403A/408A = 1°
410A/412A/415A/418A = 0.1°

*Special scaling available from 200 to 26000 counts full scale on these ranges. Consult factory.

**Lookup table can be easily developed to use "B" range below 912°F (489°C) down to room temperature. Formula in manual.

# SECTION 2

# INSTALLATION

## 2.1 UNPACKING AND INSPECTION

The Series 400A Trendicators are rugged instruments, but they must be properly packed. Originally they are shipped in a custom-designed carton, yet shipping damage occasionally occurs. When you receive your instrument inspect it. If, as you unpack it, you notice damage, stop. Ask the carrier to prepare a Damage Inspection Report and notify our Customer Service Department immediately.

If your instrument has arrived in good condition perform the functional test described in paragraph 2.4 to be sure it is operating properly.

## 2.2 REPACKING, RETURNING THE INSTRUMENT

If convenient, the original shipping container should be retained for returning instrument for repair or modification. Before returning any instrument, please contact OMEGA's Customer Service Department, and they will issue an authorized return number and shipping instructions.

a. Select a strong cardboard box of sufficient size to allow an inch of packing material around all sides of the unit.
b. Ensure the printed circuit boards are secured and the front and rear panels are firmly in place.
c. Wrap the instrument in plastic or strong paper. Place it centrally in the shipping container, and pack polyfoam, bubblepack, or rubberized hair around all six sides of the instrument.
d. Tape the carton flaps securely and label the container "FRAGILE, DELICATE INSTRUMENT". Ship it freight prepaid. Never ship by U.S. mail.

## 2.3 INSTRUMENT HOOKUP

### 2.3.1 LINE POWERED UNITS

#### 2.3.1.1 SIGNAL INPUT CONNECTIONS

All signal input connections are made to the rear of the instruments. To gain

access to the recessed termination panel, the rear plate must be removed. The four signal input terminals are located in the upper-left corner, and are marked +I, +V, -V, and -I. Hookup for the various types of signal input wires is shown in Figure 2-1. The input wires must pass through the rear panel grommet. Recom-

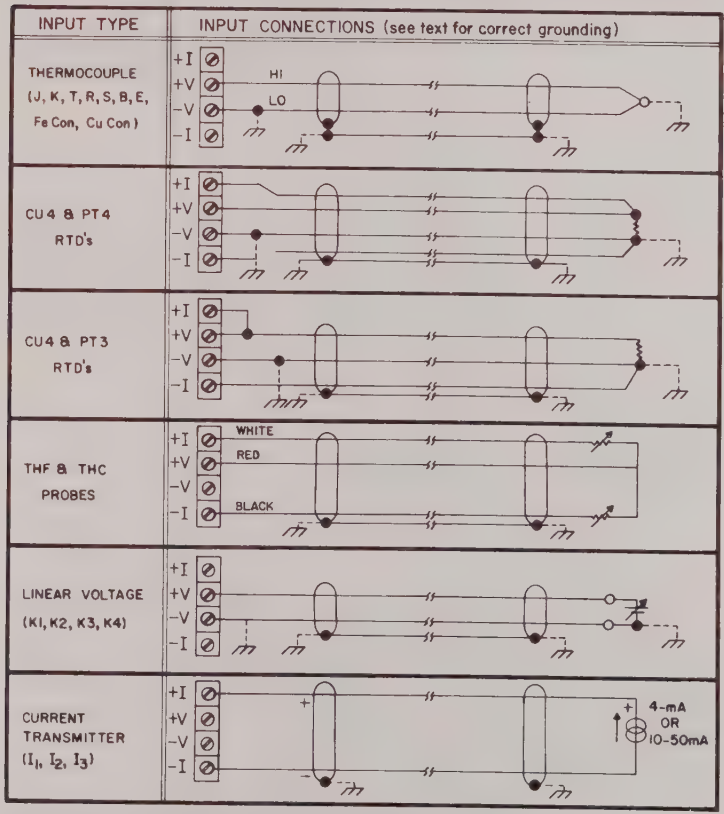



*FIGURE 2-1. SIGNAL HOOKUP DIAGRAMS*

mended points for grounding are also shown. For better noise rejection, the sensor and shield (if used) should be grounded at the source or at the instrument. Never ground sensor or shield at both points. Current transmitter (I1, I2) input wires are not normally grounded. The ground point for the instrument is located on the horizontal cross bar. (See Figure 2-2.)

Signal input terminations in the Model 402A/412A are shown in Figure 2-3. If grounding is to be done at the case, the figure shows the recommended method.

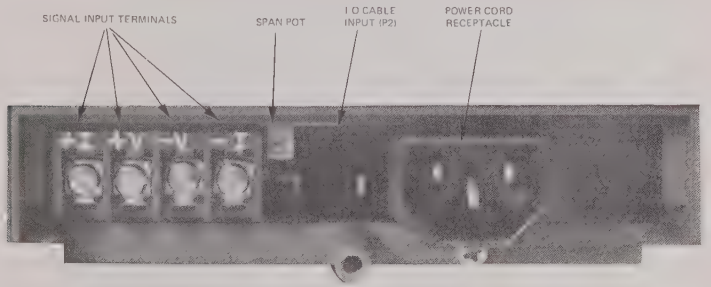



*FIGURE 2-2. REAR TERMINATION PANEL, MODEL 400A/410A.*

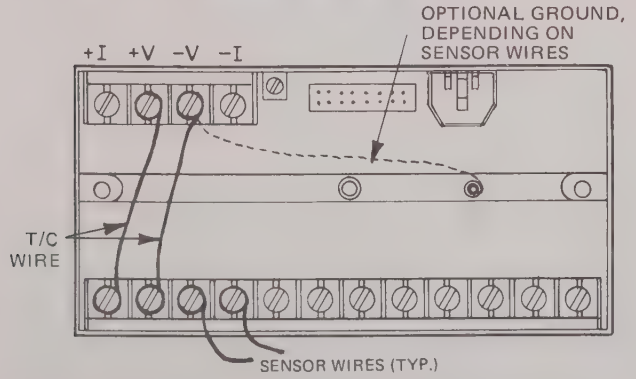



*FIGURE 2-3. REAR TERMINATION PANEL, MODEL 402A/412A.*

### 2.3.1.2 SELECTING POWER VOLTAGE

When the instrument leaves the factory, it is wired with jumpers to operate from either a 100-125 VAC or 190-250 VAC, 48-400 Hz power source as specified on the order. To change from one voltage to the other, resolder jumpers as shown in sketches below.

JUMPER FOR 230V OPERATION

JUMPER FOR 115V OPERATION

**CAUTION**

If 230V power is applied to unit wired for 115V, damage may occur.

### 2.3.1.3 RANGE PROGRAMMING

In order for a Trendicator to operate on a specific range, it must have the proper combination of analog programming module and PMOS LSI chip. The table in paragraph 1.1.1 shows the correlation. For example, to operate in the "J" range, a "J" type module and a K7500 LSI chip must be installed. Installation of the module and chip is shown in Figure 2-4. The beveled corner of the module (Pin 1) must be aligned correctly when installed (Pin 1 on module to Pin 1 on socket). When installing the PMOS LSI chip, the dot on top of the surface points away from the span and zero pots. Exercise care when installing and removing these components. For example, the best way to remove the LSI chip (to prevent lead damage) is to apply gentle upward pressure (alternating one end, then the other) with fingers or wide screwdriver.

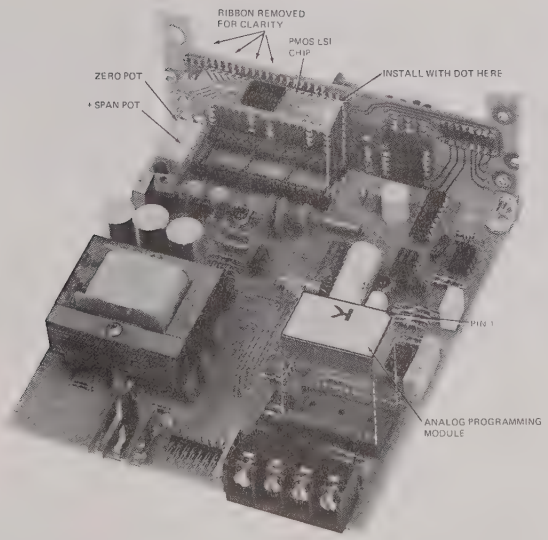



*FIGURE 2-4. INSTALLING THE LSI CHIP AND ANALOG PROGRAMMING MODULE*

### 2.3.1.4 DISPLAY PROGRAMMING

Display programming is setting the readout for °C or °F and placing the decimal point. The control for both of these settings is located behind the plexiglass front panel and just below the display as shown in Figure 2-5. The control has 6 switches, however, one pole is not used in the 1° resolution instruments.

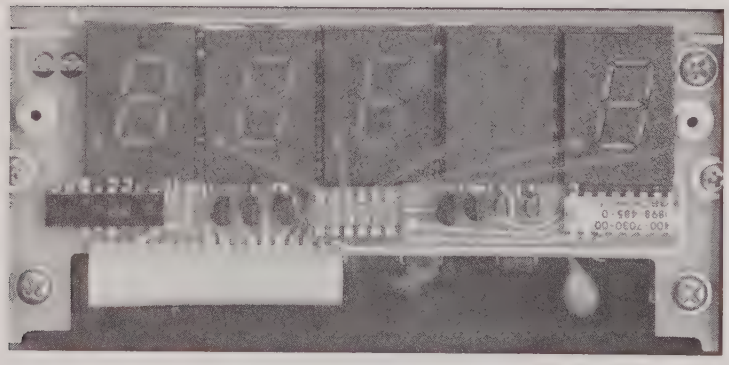


*FIGURE 2-5. SETTING THE DECIMAL POINT*

The left switch, marked C/F, controls the Celsius or Fahrenheit readout. Push in the upper button and the display reads in °C. Push in the lower button and it reads in °F. Use a ball point pen or small screwdriver to push the switches.

NOTE: For all "K" and "I" ranges set the C/F switch to F. Set the C/F switch to C for the 1000 mV range of Models 408A or 418A.

The remaining switches, marked 5, 4, 3, 2, 1, set the decimal point. To place the decimal point in the desired position, select the appropriate upper switch. The lower button turns the decimal point off. Figure 2-5 shows the correlation between the switch number and the decimal position. The photo shows five LEDs used in high resolution instruments (Models 41X). For other instruments (Models 40X), the right LED is not installed and the #1 switch is not operable.

### 2.3.2 PORTABLE BATTERY-POWERED UNITS

#### 2.3.2.1 SIGNAL INPUT CONNECTIONS

The signal input connections for Model 406 and 407 power packs are made at the front of the instrument to binding posts. Although the posts are arranged differently from the rear terminals, the connections are the same as shown in Figure 2-1. The posts are clearly marked +I, +V, -V and -I as applicable to the type of input used. Figure 2-6 identifies the posts on the Model 406.

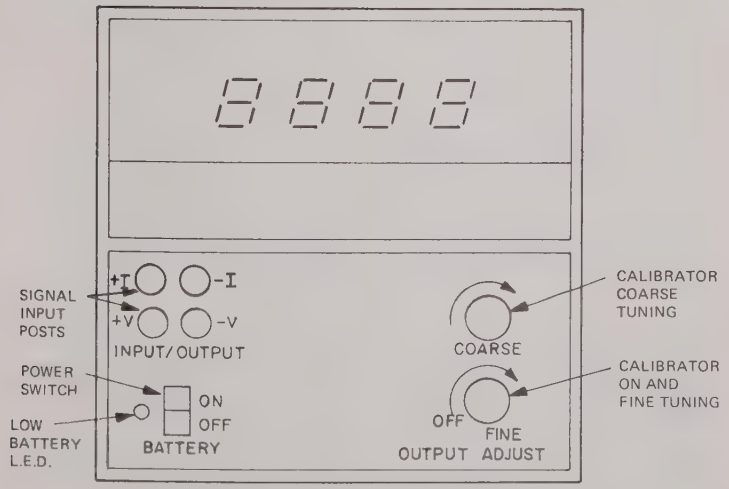



*FIGURE 2-6. FRONT PANEL, MODEL 406*

Connections to the posts may be made in several ways. If the signal wire terminates with a standard banana plug, it may be inserted directly into the end of the binding post. By unscrewing the binding post cap, signal input wires (up to 14 A.W.G.) may be terminated by wrapping around the post or by inserting the wire through the hole provided in the post. The cap should be tightened against the wire to make a secure connection.

### 2.3.2.2 LOW BATTERY INDICATION

On all battery-pack models, the low battery light is located on the front panel, just to the left of the power switch as shown in Figure 2-6. The LED illuminates automatically when the power switch is ON and the battery charge is low. The low battery light is always off when the battery is charging normally.

### 2.3.2.3 THE POWER SWITCH

The position of the power switch is shown in Figure 2-6. This rocker-type switch controls the battery power to the indicator. When the top portion of the switch is pushed in, the power is ON. Pressing the bottom portion of the switch turns the unit OFF.

### 2.3.2.4 CALIBRATION POTENTIOMETERS, MODEL 407

When the power pack/indicator unit is used to calibrate an instrument, ensure that the unit is the correct range type for the instrument being calibrated.

To prevent slow thermal drifts at the calibrator output, minimize input terminal heating and handling as much as possible when making connections.

When the output connections have been made, turn the Model 407 power switch and calibration switch ON (see Figure 2-6 for location). The upper (COARSE) knob is a 10-turn potentiometer while the lower (FINE) knob is a 1-turn potentiometer. The FINE control also serves as the ON/OFF calibrator switch.

For the zero adjustment, turn the COARSE control to the nearest readout of the desired setting as possible, then use the FINE control to obtain the precise reading. For example, a type "J" calibration might require a readout of 32°F. Then adjust the zero pot of the instrument being calibrated to 32°F. Any other calibration points may be used, since the internal digital linearization of the unit pre-compensates all predictable errors.

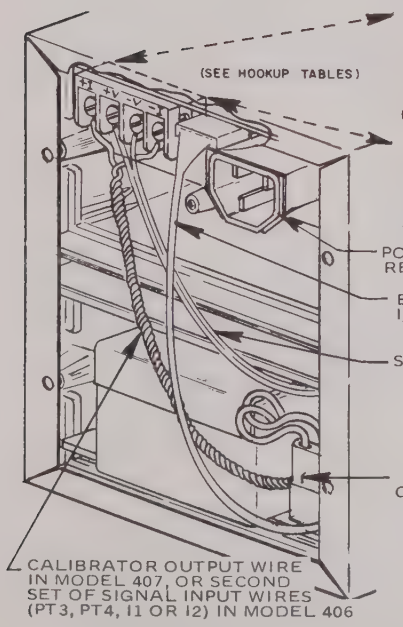
The Model 407 indicator unit may also be used for calibration while operating on line power, using the AC cord provided with the instrument. The power switch on the Model 407 may be either in the ON or OFF position, although battery charging is faster in the OFF position. The AC-operated unit operates the same as the battery-operated unit.

Except for short-term thermal effects at the input terminals, the basic accuracy of the 407 is the same as the Trendicator being used (see page 1-8).

### 2.3.2.5 INSTALLING THE TRENDICATOR IN A POWER PACK CASE

When ordered together the Trendicator and Power Pack are assembled at the factory. If shipped separately assemble as follows:

a. Remove the Trendicator rear plate. It is no longer required.


(SEE HOOKUP TABLES)
POWER INPUT RECEPTACLE
BATTERY I/O CABLE
SIGNAL INPUT LEADS
BATTERY CONNECTOR
CALIBRATOR OUTPUT WIRE IN MODEL 407, OR SECOND SET OF SIGNAL INPUT WIRES (PT3, PT4, I1 OR I2) IN MODEL 406

**MODEL 406 HOOKUP TABLE**

| RANGE TYPE | TERMINALS | | | |
|---|---|---|---|---|
| | +V | -V | +I | -I |
| TC RANGE | VARIES | RED | — | — |
| K1 – K4 | WHITE | RED | — | — |
| I1 - I3 | — | — | WHITE/ BLACK | WHITE/ RED |
| RTD & TH | WHITE | RED | WHITE/ BLACK | WHITE/ RED |

**MODEL 407 HOOKUP TABLE**

| RANGE TYPE/ CALIBRATOR WIRE | TERMINALS | |
|---|---|---|
| | +V | -V |
| TC RANGE | VARIES | RED |
| K1 RANGE | WHITE | RED |
| CALIBRATOR WIRE | YELLOW | RED |

*FIGURE 2-7. INSTALLING A TRENDICATOR IN THE POWER PACK CASE*

b. Remove the rear cover of the power pack case.
c. If there are plastic plugs in the sides of the Trendicator case, pry them out with a screwdriver; slide the Trendicator into the power pack upper section from the front.
d. Connect the battery I/O cable as shown in Figure 2-7 with the paint mark on the connector away from the circuit board.
e. Either power pack has two additional twisted-pair cables. Connect them to the Trendicator input terminals as shown in Figure 2-7 Hookup Tables. Note that only one cable is needed for TC, K, and I ranges of the 406. The 407 always uses both cables, with the red leads of both connected to -V.
f. Plug the battery I/O connector into the battery board as in Figure 2-7.
g. Install power pack rear cover.
h. Connect the AC power cord and see that the LED display lights immediately. If it doesn't, disconnect the power cord and recheck all connections, including the 115/230 jumpers. Contact Customer Service immediately if the unit still isn't working.

### 2.3.2.6 CHARGING THE BATTERY

To charge the battery, install the AC power cord into the input receptacle (see Figure 2-7) at the rear of the instrument and connect the cord to a 115 VAC or 230 VAC source. Be sure the power jumpers are in the proper position (see paragraph 2.3.1.2). The battery charges slightly faster when the battery power switch is off, but the battery charges with the switch in either position. A full charge should occur in 5-8 hours. The battery, a 10V sealed lead-acid module, may be recharged up to 500 times, depending on charge-discharge history. The unit operates about 4-8 hours continuously per charge.

### 2.3.2.7 CHANGING THE BATTERY

When it becomes necessary to replace the battery (P/N 400-4200-XX), the following guidelines are suggested.

a. Remove the rear cover of the carrying case (4 screws).
b. Remove all interconnecting cables between the indicator and power pack (see Figure 2-7).
c. Slide the indicator and power pack cases forward and out of the carrying case.

d. Disconnect the battery connector from the battery board.
e. Remove the front panel (2 screws) of the power pack and push the pack forward and out of the case.
f. On the top of the metal shield over the pack are 2 Phillips head screws. Remove these 2 screws and lockwashers.
g. Lift the end of the metal shield (the end nearest the screw holes) until the battery clears the shield.
h. Slide the old battery out and insert the new battery in the same position.
i. Re-assemble the pack. Insert the 2 screws on top the metal shield. Install the pack back into its case and replace front panel (2 screws).
j. Plug the battery connector into its battery board contact.
k. Slide both indicator and battery cases back into carrying case.
l. Connect I/O cable and signal input wires.
m. Place rear cover over back of carrying case, aligned screw holes, and install 4 screws.

### 2.3.2.8 MODEL 407 POTENTIOMETER OPERATION

The model 407, after being calibrated per the procedures in section 4, can be used as a precision source for voltage or equivalent thermocouple output. Output impedance in all cases is ten ohms.

a. Millivolt Source: The 407 with a K1 range will output -10 mV to +26 mV, or the full K1 range. The readout on the display accurately represents the voltage at the front panel binding posts. The post material is brass, and care must be taken to use low thermal connections (copper wire) to avoid parasitic thermocouple effects. Calibrate the external unit at the points desired by adjusting the coarse and fine controls until the Trendicator reads the approriate voltage. Output voltage is the same on float charge or battery operation (if low light is "ON," however, make sure that display is stable or place unit on line operation to avoid runaround).

b. Thermocouple Transfer Standard: A 407 equipped with a thermocouple range may be used as a precision, linearized voltage source for thermocouple indicator calibration. Only the range type designated by the Trendicator front panel may be calibrated accurately, however, Reference junction integrity can be maintained by assuring that the appropriate thermocouple lead wire or extension wire is used to connect the 407 to the unit being calibrated. For low level thermocouples, such as S, R, and B, thermal effects on the input terminals may cause some error. To avoid drafts, place a cloth over the input terminals if necessary. In most cases, less than 5 minutes is required for enough stabilization for a precision calibration.

## 2.4 CHECKOUT PROCEDURE

A Trendicator functional checkout may be made as follows:

a. Remove the rear cover.
b. For thermocouple and K1-K4 ranges short all input terminals with copper wire (NOTE 1). Connect RTD ranges per NOTE 2, and TH ranges per NOTE 3. Leave terminals open on I ranges.
c. Apply power to the Trendicator. The display should approximate the appropriate readout in the table below.

| INPUT TYPE | SIGNAL INPUT TERMINALS | READOUT |
|---|---|---|
| Thermocouples (see note 1) | shorted | room temperature |
| RTD | (see note 2) | 0°C or 32°F |
| K1, K2, K3, K4 | shorted | 0 ± 10 μV |
| I1, I2 | open | -25.00% |
| $I_3$ | open | -0.25 Span + (Offset) |
| THC/F | (see note 3) | 0°C/32°F |

NOTE 1: For "B" thermocouple range, simulate the TC input with a millivolt calibrator. Example: a 4.833 mV input should produce a display of about 1832°F (1000°C).

NOTE 2: Connect +V and +I, and -V and -I. Connect a resistor equal to the RTD $R_0$ between +V and -V.

NOTE 3: Connect two resistors, 25.45KΩ from +I to +V, 100K from +V to -I.

## 2.5 MOUNTING THE INSTRUMENT

### 2.5.1 PANEL MOUNTING

For panel mounting each instrument is supplied with a mounting bracket, installed as shown in Figure 2-8. The instrument bezel flange butts against the front of the mounting panel; the mounting bracket fits over the instrument rear panel. The bracket screws force it against the rear of the mounting panel, locking the instrument in place. Panel cutout dimensions are 5.43" (138.0, +1-0 mm) x 2.67" (68.0, +0-7 mm).

### 2.5.2 BENCH MOUNTING (OPTION W5)

Option W5 is a bench mounting with 4 rubber feet and a pivot to change the vertical viewing angle. It is shown in Figure 2-9.

### 2.5.3 RACK MOUNTING (OPTION W6)

Rack mounting adaptors 3.5" (90mm) x 19" (483mm) are available with openings for 1, 2, or 3 Trendicators, which are installed with panel mount brackets as described in Paragraph 2.5.1. Rack adaptor mounting is illustrated in Figure 2-10.

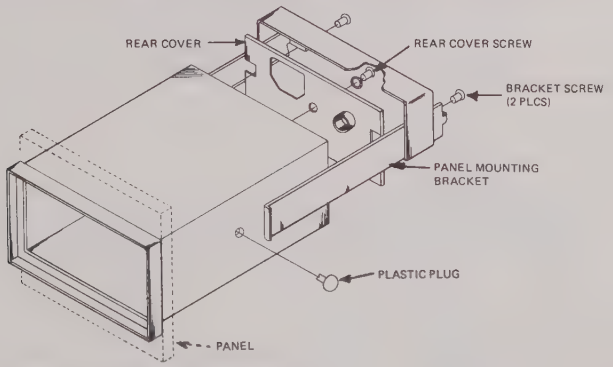



*FIGURE 2-8. PANEL MOUNTING HARDWARE*

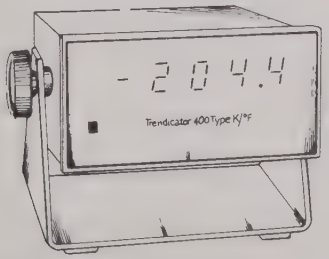



*FIGURE 2-9. BENCH MOUNTING HARDWARE*

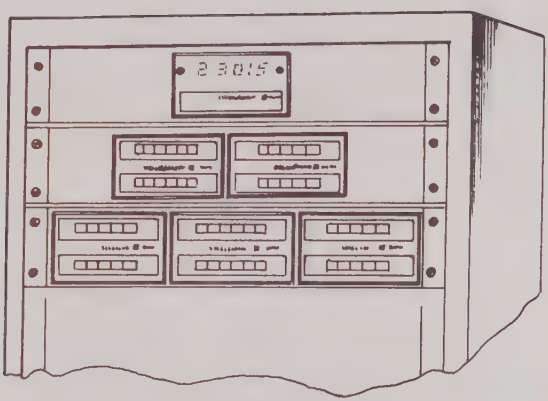


*FIGURE 2-10. TRENDICATORS IN RACK-MOUNTED W6 ADAPTORS*

## 2.6 OPERATING GUIDELINES

### 2.6.1 INSTRUMENTATION TURN-ON

Before any Series 400A Trendicator is turned on the input transducer should be connected. The desired range of a multi-range Trendicator (403A, 408A, 415A, or 418A) should be selected before turn-on, since the display may lock up if ranges are switched with the power on.

"B" range instruments with 0.1° resolution (410A, 412A, and 415A) may lock up if a positive overrange occurs. To unlock the display remove the overload and turn off the power switch, then turn it on again.

Applying power to any instrument with an "I" range (400A, 402A, 410A or 412A) without an input transducer connected may lock up the display. To correct the condition turn off the power, complete the input circuit and turn on the power.

When changing ranges on any Series 400A instrument, turn off the power while the range change is made and the sensor is rewired, to eliminate shock hazard.

## 2.7 OPTIONAL FEATURES INSTALLATION

### 2.7.1 MODEL 405A AND 409A INSTALLATION

When a Model 405A is used with the 400A/410A, signal leads connect to 10 terminal pairs at the rear of the 405A. All 405A outputs (+ and –) connect to the +V and –V terminals as shown in Figure 2-11A.

The Model 409A, shown in Figure 2-11B, uses 4 input terminals for PT-100 ranges. Connections are usually made to the Fanning strips provided with the 409A (4-terminal is P/N 973-010-044; 6-terminal is P/N 973-010-045).

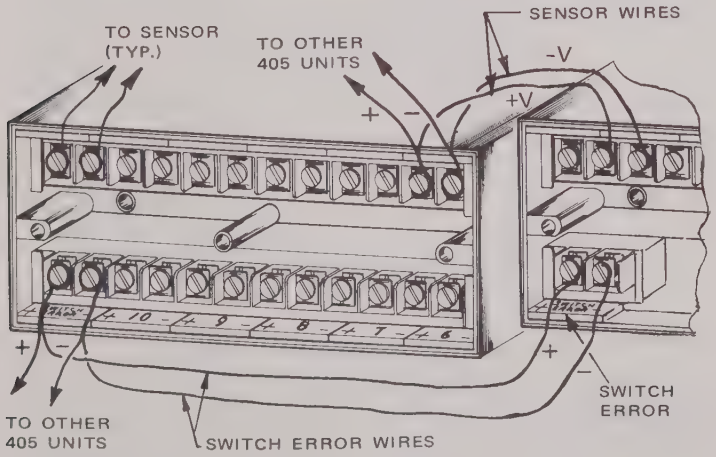



*FIGURE 2-11A. INTERFACE BETWEEN MODELS 400A/410A AND 405A.*

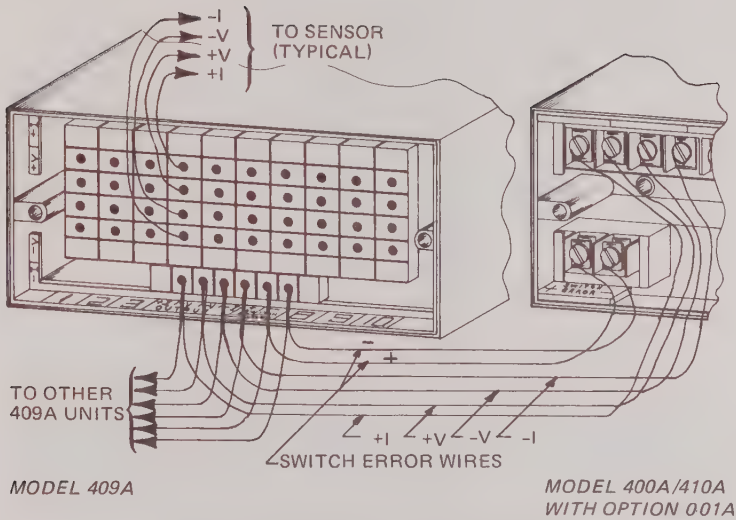



*FIGURE 2-11B. INTERFACE BETWEEN MODELS 400A/410A AND 409A.*

### 2.7.2 SWITCH ERROR INDICATOR BOARD INSTALLATION

When ordered with the 400A/410A, Option 001A is installed. If it is shipped separately, install it as follows:

a. If the Trendicator is panel mounted remove the mounting bracket and rear cover.
b. Mark all wires to insure correct replacement. Then disconnect them from the Trendicator terminals.
c. Remove the two screws that secure the front plexiglas panel.
d. Remove the 2 front screws that fasten the display board to the chassis.
e. Slide the display board assembly forward until it can be turned over, component side up.
f. Refer to Drawings 400-4190-XX and 400-4420-XX. Plug J1 of 400-4420-XX into P2 of 400-4190-XX, paint stripe away from 400-4190-XX.

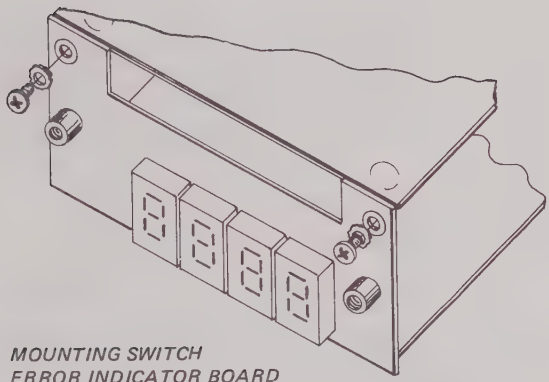


*FIGURE 2-12. MOUNTING SWITCH ERROR INDICATOR BOARD*

g. Invert 400-4420-XX, place it over 400-4190-XX, and attach it to the display board as shown in Figure 2-12 with the screws and lockwashers included in the kit.
h. Slide the display board back inside the chassis and reassemble the Trendicator, reconnecting the wires.
i. Place the label (included in the kit) below the Switch Error Terminals as shown in Figure 2-11.
j. Wire switch error circuits according to Figure 2-11A or B.

### 2.7.3 DATA OUTPUT BOARD INSTALLATION

Option 002A adds parallel BCD outputs to Model 400A/410A Trendicators. It is installed inside the instrument, and includes a 30-pin mating connector with hood. It may be ordered for field installation in a 400A or 410A, but cannot be used with the 402A, 403A, 408A, 412A, 415A, 418A or a 400A/410A which uses an Option 001A, 003A, 004A, 005A, 406 or 407.

Data output connections are shown in Figure 2-13. All outputs are $T^2L$ compatible, and fanout is two standard $T^2L$ inputs. Input commands may be standard $T^2L$, but only 250 $\mu$A sink current is required so all lines are also CMOS compatible.

Data outputs are positive true 1-2-4-8 BCD. Cable connections are shown in Figure 2-13. Note that terminals A, B, C, and D are unused with the 400A, since it is a 3 1/2 digit instrument.

Although the data output is fully isolated from the Trendicator sensor input and power line connections, good wiring practices should be followed for cabling outputs. Both data common and chassis ground are provided for cable shielding. Also, the command lines DAR and HOLD should not be too closely bundled to the data output lines to prevent possible crosstalk. Maximum recommended cable length is 25 feet from Trendicator to peripheral unit. Data output cables should also be kept away from sensor input wires to prevent possible crosstalk.

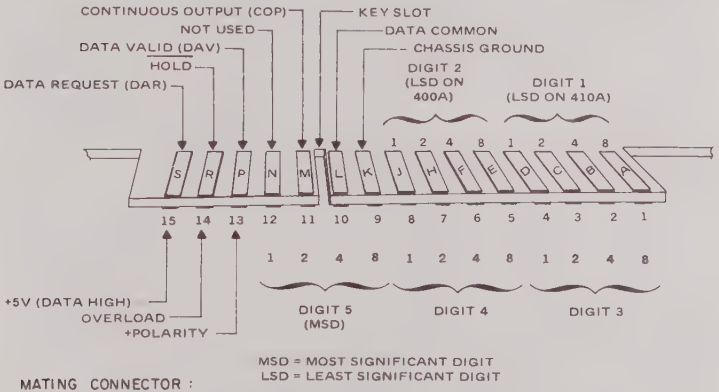

CONTINUOUS OUTPUT (COP)
NOT USED
DATA VALID (DAV)
HOLD
DATA REQUEST (DAR)
KEY SLOT
DATA COMMON
CHASSIS GROUND
DIGIT 2 (LSD ON 400A)
DIGIT 1 (LSD ON 410A)
S R P N M L K J H F E D C B A
1 2 4 8 1 2 4 8
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
1 2 4 8 1 2 4 8 1 2 4 8
+5V (DATA HIGH)
OVERLOAD
+POLARITY
DIGIT 5 (MSD)
DIGIT 4
DIGIT 3
MSD = MOST SIGNIFICANT DIGIT
LSD = LEAST SIGNIFICANT DIGIT
MATING CONNECTOR :
SAE SCC15/DI-2

*FIGURE 2-13. DATA OUTPUT PIN ASSIGNMENTS (OPTION 002A)*

The + polarity line is independently "true" (high) for positive displays, and "false" (low) for negative displays.

Overload is "true" (high) for an overload (over scale or broken sensor) indication on the display (all dashes), and "false" (low) for normal in-range readings.

Data common is provided for logic low reference, as is the data outputs' +5V supply for logic high reference. Current capability of the +5V output is 500 $\mu$A maximum which allows up to 10 unused $T^2L$ inputs to be wired high externally.

Timing for the data valid is shown in Figure 2-14. The positive going edge of DAV should be used for triggering an external printer or other device. The DAV pulse is low for approximately 3.5 msec during the data update, and no BCD outputs should be taken during this period.

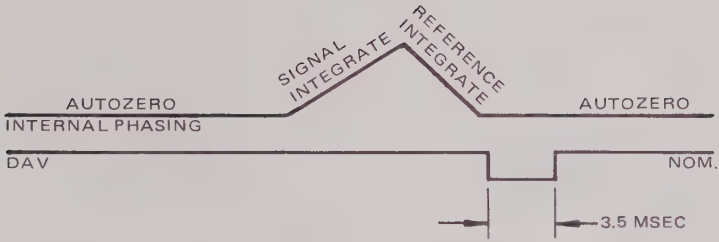



*FIGURE 2-14. OPTION 002A, DATA OUTPUT TIMING DIAGRAM*

If the DAR line is held high indefinitely, no further DAV transitions occur after the first. If continuous DAV updates are desired for each encoding (that is, for a DAV interrupt scheme), the continuous output (COP) may be wired or switched directly to the DAR command line. In this mode a DAV update occurs after every encoding.

Unless the command line $\overline{\text{HOLD}}$ is low (ground contact closure), the Trendicator takes continuous readings as in normal operation. When $\overline{\text{HOLD}}$ is taken low, the last readings are displayed indefinitely, and no new conversions are made. In this mode, DAV is high continuously. Displayed data is valid on the output lines, however, and could be utilized if desired.

The normal command for data output is the data request (DAR) line. If the unit is not in hold ($\overline{\text{HOLD}}$ = 1 or open), then a positive edge transition on DAR causes one subsequent DAV output pulse at the next completed encoding time. Each positive edge on DAR causes only one DAV update if the DAR pulse conforms to Figure 2-15.

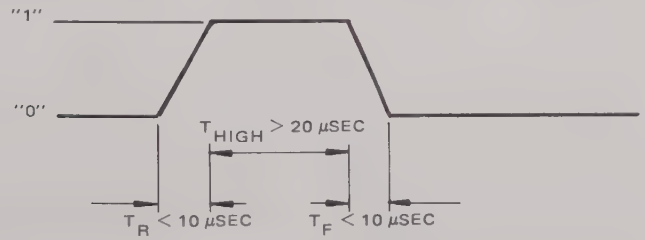
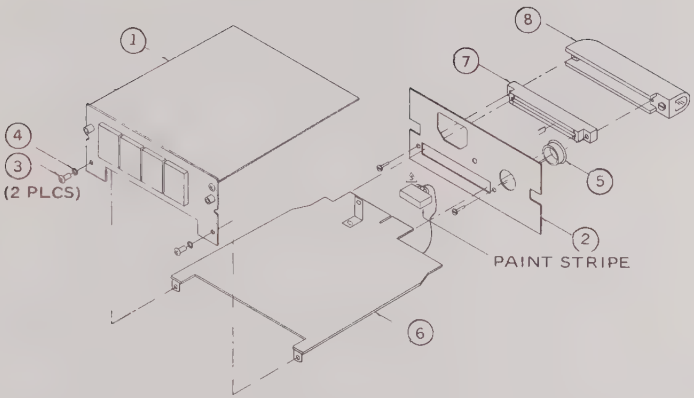



*FIGURE 2-15. DAR COMMAND FORMAT*




(CASE NOT SHOWN FOR CLARITY)

| | |
|---|---|
| 1 | MAIN BOARD |
| 2 | REAR PANEL |
| 3 | 6-32 X 1/4 PHMS |
| 4 | NO. 6 LOCK WASHER |
| 5 | NYLON GROMMET |
| 6 | DATA OUTPUT BOARD |
| 7 | CONNECTOR, DATA OUTPUT |
| 8 | HOOD, CONNECTOR |

*FIGURE 2-16. DATA OUTPUT INSTALLATION*

# SECTION 3

# THEORY OF OPERATION

## 3.1 INTRODUCTION

The Trendicator 400A accepts a variety of inputs (thermocouple, voltage, current, resistance) and converts them to degrees or other engineering units. Dual slope integration is used for low noise and auto-zero circuitry assures drift- free performance.

The 400A Trendicator utilizes (LSI) PMOS semiconductor technology. All digital logic including thermocouple and RTD linearization tables is contained in one of two optional ion-implanted PMOS integrated circuits. A solid-state planar LED display is driven by on-chip decoders. Strobes provide a bright digital indication in degrees Fahrenheit or Celsius, or other engineering units.

## 3.2 DUAL SLOPE A/D CONVERSION

Refer to the schematic of analog circuits (Figure 3-1) and diagram of dual slope technique (Figure 3-2). Before each conversion ($T_o$), S2 and S3 are closed. The auto-zero and zero-cross detector circuits "close the loop" around the integrator, establishing a starting point for the integration.

During $T_1$, $S_2$ and $S_3$ are opened, S1 is closed, and the integrator is allowed to ramp up (down for + $E_{IN}$). After a known number of clock pulses S1 is opened, S2 is closed, and a short pause occurs to settle capacitor charging.

During $T_3$, S5 is connected (S4 if + $E_{IN}$) and the integrator ramps back toward zero at a constant rate. The amount of time (counts) required to return to zero is proportional to the input voltage. After zero-crossing the system returns to auto-zero.

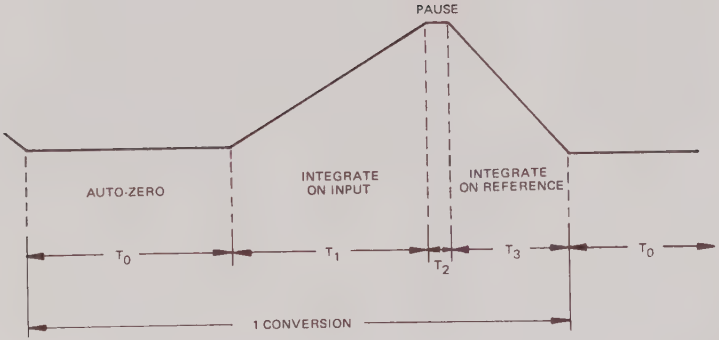



*FIGURE 3-1. DUAL SLOPE TECHNIQUE*

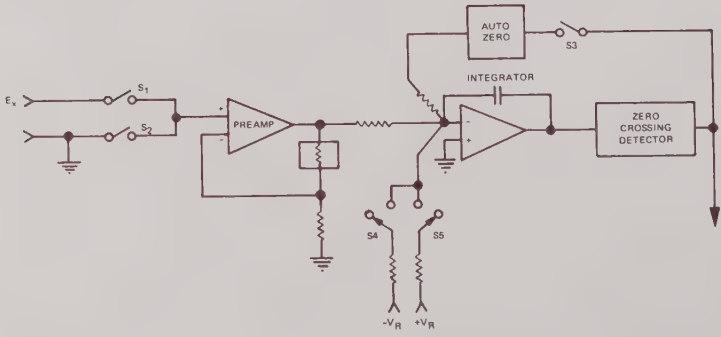



*FIGURE 3-2. ANALOG CIRCUITS SHOWING AUTO-ZERO*

## 3.3 CIRCUIT DESCRIPTION

### 3.3.1 POWER SUPPLY AND REGULATOR

Refer to schematic 400-6180 or 400-6190 in back of manual. AC power is connected at P1, filtered for RFI, and connected to the power transformer, T1. The rectified secondary voltage provides +11 VDC on C4 and C5 (LED display power) and -11 VDC on C6. The two amplifiers of Z8 drive pass transistors Q1 and Q2. If excessive current is drawn through Q1 or Q2 resistors R3 and R9 limit the peak currents, thus protecting the supply.

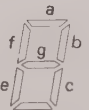
Potentiometer R13 adjusts the power supply voltage. Positive span is adjusted with R45 with the front panel removed, and negative span is adjusted independently by R14 with the rear cover removed.

### 3.3.2 DISPLAY AND DRIVER

The seven segments (a through g, see sketch below) of the common-cathode LED displays are driven by seven emitter-follower Darlington transistors (Q9 through Q15). Current is limited by Z11 (resistor network) to illuminate segments a through g. Z10 provides digit drive and selection at the appropriate multiplex time.

Level shifter Q8 is used for leading zero blanking control in conjunction with S2. "DIP" switch S2 is used to select drive to an appropriate decimal point for the range being used. One pole of S2 may also be used to configure °F or °C display for any of the temperature measuring ranges.

*DISPLAY SEGMENTS*




### 3.3.3 DIGITAL LOGIC

Z9 is a PMOS digital integrated circuit operating from the regulated +7.2 and -7.2 voltages. Pins 15 through 20 are digit strobes for driving digit selection drivers. Pins 23 through 29 provide segment data for generating the display. Pin 6 of Z9, a clock input, receives the 400 kHz clock, generated by C18, R38, R39 and Z7 pins 11-15. Pin 33 is a power-on reset pin used in conjunction with R41 and C21. Pin 33 clears internal logic and prepares the dynamic logic for the first conversion. Pin 35 is the "start convert" line and delays conversion by a time constant generated by Q7, R40 and C20. Pins 37 through 40 provide the A/D conversion switching logic (see block diagram, page 3-2) for S5, S4, S3, and S1. Pins 6 through 9 of Z9 are used in conjunction with the analog program module (J3) to configure the unit for the appropriate range type.

### 3.3.4 ANALOG OPERATION

The Analog Program Modules (APM) condition, scale, and offset various range inputs. For thermocouples a reference junction, gain scaling and break detection circuitry are provided. Current sources and bridge complition are included for PT, CU and TH ranges. Scaling and filtering for K ranges, and shunt and offset circuitry for I ranges are also provided.

The input filter consists of R15, R46, R47, and C9, C10, and C11. The input to Z2 is alternately switched from the filtered input to R17. Potentiometer R19 gives an adjustable low level offset through voltage divider R18 and R17. R21 and R20 provide offset adjustment for low level preamplifier Z2. Gain feedback resistor is contained on the APM between APM pins 2 and 23. R25 and R33 provide reference current for reference integration as switched by Z3. C22 compensates Z4 (400's). Z5 is the auto-zero preamplifier, R34 and R35 set the gain for Z5. R31, R32 and C14 are compensation and hold components for auto-zero error correction. Pins 8 and 9 of Z3 provide the S3 switching function. R29 adjusts the DC level and R30 provides the bias for Q6, a source follower. R24 couples the error correction to the summing node. Q3 and the APM generate reference junction correction current for thermocouple ranges. This current and bridge completion offsets for other ranges, are fed from the APM pin 8 to the integrator summing node via series CMOS switch. Z6 and Z7 pins 10 and 9, plus positive feedback (hysteresis) resistors R36 and R37 comprise the zero crossing detector circuitry.

I/O connector P2 provides interface connections for power pack and BCD options.

### 3.3.5 POWER PACKS 406 AND 407

Refer to schematic 406-6200 or 407-6100 in back of manual. The two power pack options contain circuitry for float charging the sealed lead-acid cells, as well as circuitry for converting the battery voltage into a usable form for the main board power supply.

C1, C2, CR1, and C3 provide a voltage doubling of the raw AC signals from the transformer on the main board. Z3 is a protected constant voltage regulator, which is trimmed to the nominal charge voltage of 11.75V at the anode of CR4. R1, R2, and R3 adjust the voltage of Z3, and CR4 protects Z3 from battery current when not in a charging mode. Switch SW1 disconnects the battery from loads in the "OFF" position (open). Resistors R4 and R5, and Op-Amp Z1 Pins 12, 13, and 14 put a "trickle" load on the battery to sense low voltage. If the unit is on, and the battery drops below about 9.3 volts, LED CR8 is turned on and current limited by R7. The raw battery voltage is fed back to the + unregulated node of the main board by CR2. This voltage is in parallel with any unregulated voltage that may be supplied by the transformer on the main board.

Z2, C4, and R6 form a free running oscillator and driver for Q1 and Q2 at about 5 kHz. Q1 and Q2 provide a "charge pump" effect to generate the lower current - unregulated supply through CR5, CR6, CR7, C5, C6, and C7. This voltage is decoupled from the main board with CR3.

Front panel inputs on the 406 and 407 are wired internally to the rear input terminals on the main board. For thermocouple units, appropriate thermocouple extension wire is used for this purpose to maintain reference junction integrity to the front binding posts.

The Model 407 contains additional circuitry for calibration output. 10-turn wirewound pot R10 provides a stable "coarse" adjust. R10 is biased correctly by R8, R9, and R11. R13 injects offset current to R10 via pot R12, thus providing a fine adjustment. R12 is a single-turn composition unit ganged with a two-pole switch SW2. With R12/SW2 in the most counterclockwise position, SW2 pins 1 and 2 are open, disconnecting the calibrator output from both the Trendicator and the front panel terminals. The unit is used as a conventional indicator in this mode. SW2 pins 3 and 4 effectively short the calibrator, preventing interactive ground currents from flowing. Z1 pins 10, 9, 8 provide high impedance referencing of the pot circuit to ground, Z1 pins 2, 3, 1 provide a buffered output and drive the output divider R14 and R15. Z1 pins 5, 6, 7 and R16, R18, and R17 generate an opposing current to the output divider and prevent offset from occurring in return wires to the Trendicator.

### 3.3.6 ISOLATED DATA OUTPUT OPTION 002A

Option 002A provides fully isolated parallel digital outputs which are $T^2L$ compatible. The LSI device (Z9) on the main 400A board generates a serial BCD output on pin 32. This data is in a pulse width modulated format and includes polarity and overload information. The data enters the 002A board through J1 pins and is level shifted and amplified by R3, R4 and Q3. Opto isolator Z1 is driven by Q3 and provides isolation of data. The receiving side of Z1 is shaped and buffered by R10 and Z3 (7, 6). The pulse width modulated data (6 4-bit words) is inverted by Z3 (14, 15) and presented to the input to a 24 bit shift register comprised of Z6, Z7, and Z8.

Clocking information for the shift register is provided by pin 7 of one-shot Z4. One shot time is adjusted for ~7 $\mu$sec which is halfway between a "1" and a "0" pulse width. Thus, a "1" or "0" is clocked into the shift register for each data pulse.

The second half of one-shot Z4 (pin 10) provides a 3.5 msec pulse triggered off the first data bit. This pulse is slightly wider than the entire 24-bit shift sequence and disables the data valid (DAV) output flag until data shifting has been completed. When DAV goes true (high) all parallel digit outputs are stable and can be read correctly by an external printer or peripheral.

Command control of the data is handled with two lines. $\overline{\text{HOLD}}$ sets the R-S flipflop comprised of Z5 (1, 2, 3) and Z5 (11, 12, 13). This flipflop is reset at every update period unless the HOLD line is held low. When the flipflop is set, A5 is "on" and Opto Z2 is also on. FET Z4 also turns on and forces pin 35 of Z9 on the main board high, or in a continuous hold position. When $\overline{\text{HOLD}}$ is released, the main board one-shot of Q7, R40, and C20 functions normally and begins a new encoding.

The data request (DAR) line requests a positive edge to initial BCD data updating. This edge is detected by Z13 (3) and latched by Z13 (9). Z13 is reset with the 3.5 msec pulse from Z4 (10) after every ready. To eliminate the necessity for continuous positive edges on the DAR if continuously updated output is desired, the continuous output pin (COP) is provided. If this line is switched to DAR, BCD output updates automatically with each encoding.

The power supply for the 002A option is derived from the main board 400 kHz clock. This square wave is buffered by Q1 and Q2 and isolated with C2, R2, and T1. The signal is rectified and filtered on T1's secondary by CR2, CR3, CR4, CR5, and C5. Zener CR6 regulates the output to provide a TTL compatible supply and logic reference.

# SECTION 4

# CALIBRATION

## 4.1 TEST EQUIPMENT

a. Thermocouples: a DC calibrator capable of supplying voltages up to 100 mV with better than one microvolt resolution is required. A stable ice bath, accurate to 0.05°F, is also needed.

b. K1, K2, K3, K4 Ranges: a DC calibrator (see item a above) is required, except an output of up to 25V is necessary (K4 range).

c. $I_1$, $I_2$, $I_3$ Ranges: a current calibrator with 1 $\mu$A resolution from 4 to 50 mA is required.

d. RTD Ranges: 000.00 to 400.00 ohm calibration pot with 0.01 ohm resolution is required.

e. TH ranges: 1000.0 to 30,000.0 ohm calibration pot with 1.0 ohm resolution is required.

## 4.2 CALIBRATION PROCEDURE

In all cases, allow instrument to warm up for 30 minutes before calibrating.

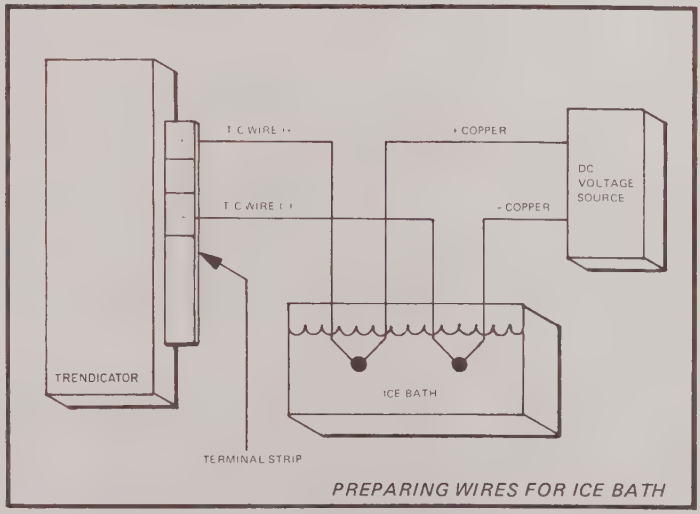
### 4.2.1 THERMOCOUPLES

a. Connect the DC calibrator and ice bath to the Trendicator as shown in the set-up diagram.

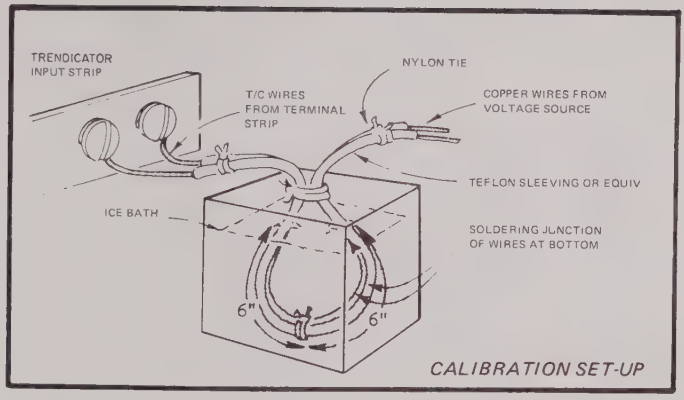
b. Prepare test wires for ice bath as shown.

c. Refer to calibration chart and perform calibration.

EXAMPLE: For Type K thermocouple. Connect the DC calibrator to Trendicator +V and -V. Apply 0.000 mV and adjust Front Panel Zero (R44) to give a display of 32°F or 0°C. Apply 54.845 mV and adjust + Span (R45) to give a display of 2500°F. R44 and R45 are visible at the upper left of the display with the front panel plexiglas removed.




*PREPARING WIRES FOR ICE BATH*




NOTE: The B thermocouple output below 912°F (488°C) is only 1.3 μV/°F (2.4 μV/°C). While the Trendicator linearity is excellent above 912°F, the "B" μV table will better approximate lower temperatures.

### 4.2.2 K1, K2, K3, K4 LINEAR VOLTAGE RANGES

a. Connect the DC calibrator to the +V and –V terminals of the Trendicator.

b. Refer to calibration chart and perform calibration.

### 4.2.3 I1, I2 AND I3 CURRENT TRANSMITTER RANGES

a. Connect the current calibrator to the +I and –I terminals of the Trendicator.

b. Refer to calibration chart and perform calibration.

| RANGE | SENSOR TYPE | INPUT | ADJUST | READ | INPUT | ADJUST† | READ | INPUT | READ |
|---|---|---|---|---|---|---|---|---|---|
| J | Iron-Constantan | 0 mV<br>0 mV | Zero<br>Zero | 32°F<br>0°C | 39.407<br>42.283 | Span<br>Span | 1300°F<br>750°C | -7.519<br>-7.659 | -300°F<br>-190°C |
| K | Chromel-Alumel | 0 mV<br>0 mV | Zero<br>Zero | 32°F<br>0°C | 54.845<br>52.398 | Span<br>Span | 2500°F<br>1300°C | -4 381<br>-3 553 | -200°F<br>-100°C |
| T | Copper-Constantan | 0 mV<br>0 mV | Zero<br>Zero | 32°F<br>0°C | 20.801<br>20.252 | Span<br>Span | 750°F<br>390°C | -5 341<br>-5 439 | -300°F<br>-190°C |
| R | Platinum –<br>Platinum 13%<br>Rhodium | 0 mV<br>0 mV | Zero<br>Zero | 32°F<br>0°C | 19.518<br>20.878 | Span<br>Span | 3000°F<br>1750°C | –<br>– | -<br>- |
| S | Platinum –<br>Platinum 10%<br>Rhodium | 0 mV<br>0 mV | Zero<br>Zero | 32°F<br>0°C | 17.347<br>18.504 | Span<br>Span | 3000°F<br>1750°C | –<br>– | – |
| B | Platinum 30%<br>Rhodium<br>Platinum –<br>6% Rhodium | 0 mV<br><br>0 mV | Zero<br><br>Zero | 32°F<br><br>0°C | 13.763<br><br>13 585 | Span<br><br>Span | 3300°F<br><br>1800°C | –<br><br>– | – |
| FeCon | Iron-Constantan<br>(DIN) | 0 mV<br>0 mV | Zero<br>Zero | 32 0°F<br>0 0 C | 53 064 mV<br>50 320 mV | Span<br>Span | 1650.0°F<br>860 0°C | -8 022 mV<br>-8.006 mV | -320.0°F<br>-195 0°C |
| CuCon | Copper-Constantan<br>(DIN) | 0 mV<br>0 mV | Zero<br>Zero | 32.0°F<br>0.0°C | 31 492 mV<br>33 954 mV | Span<br>Span | 1040.0°F<br>595 0°C | -5.405 mV<br>5.510 mV | -300.0°F<br>-190 0°C |
| E | Chromel-Constantan | 0 mV<br>0 mV | Zero<br>Zero | 32.0°F<br>0 0°C | 81.273 mV<br>76 357 mV | Span<br>Span | 1950.0°F<br>1000 0°C | -8.768 mV<br>-8 273 mV | -324 0°F<br>-180 0°C |
| PT 3, PT 4 | Platinum<br>100Ω RTD | 100.00Ω<br>100.00Ω | Zero<br>Zero | 32.0°F<br>0 0°C | 390 38Ω<br>390 38Ω | Span<br>Span | 1562.0°F<br>850.0°C | 18.53Ω | -328.0°F<br>-200 0°C |
| CU3, CU4 | Copper RTD | 9.04<br>6.73<br>9.04<br>6.73 | Zero<br>-Span<br>Zero<br>-Span | 32°F<br>-76°F<br>0°C<br>-60°C | 16.91<br><br>16.74 | +Span<br><br>+Span | 400 0°F<br><br>200.0°C | – | - |
| TH | Thermistor | T1-100K<br>T2-25 425K | Zero | 32°F | T1-100K<br>T2-1.602K | +Span | 212°F | – | – |
| TC | Thermistor | T1-100K<br>T2-25.425K | Zero | 0°C | T1-100K<br>T2-1.602K | +Span | 100°C | – | - |
| I1 | 4-20 mA Transmitter | 4.000 mA | Zero | - 00% | 20 000 mA | Span | 100 00% | – | - |
| I2 | 10-50 mA Transmitter | 10.000 mA | Zero | -.00% | 50.000 mA | Span | 100.00% | – | – |
| $I_3$ | 4 20 mA Transmitter | 4 000 mA | Offset* | | 20.000 mA | C & Fine Span* | | | |
| K1 | -10 mV to +25 mV<br>Linear | 0 mV | Zero | -.000 mV | 25 000 mV | Span | 25.000 mV | -10.000 mV | -10 000 mV |
| K2 | -100 mV to +250 mV<br>Linear | 0 mV | Zero | -.00 mV | 250.00 mV | Span | 250 00 mV | -100.00 mV | -100 00 mV |
| K3 | -1V to +2.5V Linear | 0 mV | Zero | -.0000V | 2 5000V | Span | 2.5000V | -1.0000V | -1.0000V |
| 1000 mV<br>(408, 418) | -0.5V to +1.0V<br>Linear | 0 mV | Zero | -.0 mV | 1.0000V | Span | 1000 0 mV | -500 0 mV | -500.0 mV |
| K4 | -10V to +25V | 0 mV | Zero | - 000V | 25.000V | Span | 25.000V | -10.000V | -10.000V |

†Although minus span adjust is normally not required, R14 may be adjusted.

## *CALIBRATION CHART*

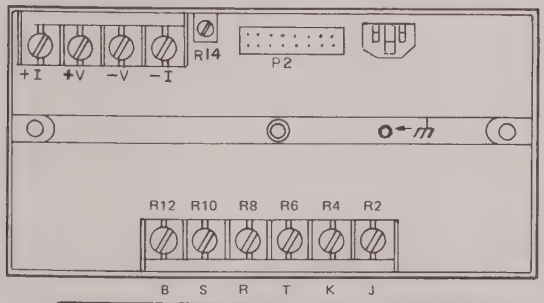
*These adjustments are on the $I_3$ module. If necessary, use the ZERO and SPAN adjustments on the Trendicator to attain the desired readings. Adjust $I_3$ Offset, then Trendicator Zero to get the desired offset, then adjust $I_3$ Coarse and Fine, and Trendicator Span in that order for desired span. Recheck the offset with 4 mA. If it has changed, repeat the adjustments, since they may interact.

### 4.2.4 RTD AND TH RANGES

a. Connect resistor(s) as indicated in Figure 2-1.
b. Refer to calibration chart and perform calibration.

### 4.2.5 MULTIRANGE UNITS

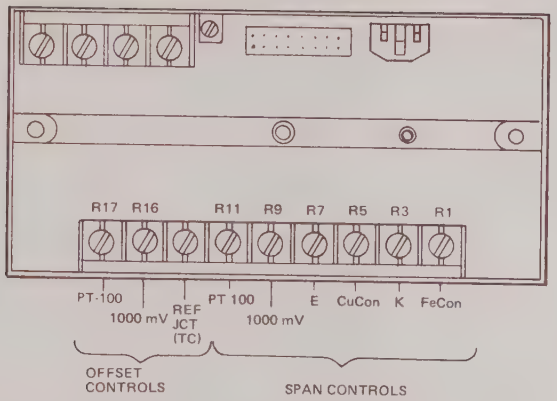
The following charts list the calibration steps for multifunction instruments. Both ice point and full scale must be adjusted for any range used. Since up to 5°F variation in ice point output among several thermocouples can occur, it may be necessary to re-adjust ice point for the particular TC being used (particularly common with types R, S, and B). Always adjust ice point before adjusting full scale. Minus span adjust R14 (main board) may be adjusted if desired for a particular range, but is common to all ranges. Inputs and nominal calibration values are the same as shown in the calibration chart for single function units.




| TC TYPE | ICE POINT ADJUST | FULL SCALE ADJUST |
|---|---|---|
| B | Zero* | R12 |
| J | Zero* | R2 |
| K | Zero* | R4 |
| T | Zero* | R6 |
| R | Zero* | R8 |
| S | Zero* | R10 |

*Zero adjust is on front panel

*CALIBRATION STEPS, MODELS 403A, 415A*




| RANGE TYPE | ZERO ADJUST | FULL SCALE ADJUST |
|---|---|---|
| Fe Con | Zero* | R1 |
| K | Zero* | R3 |
| Cu Con | Zero* | R5 |
| E | Zero* | R7 |
| PT3, PT4 | PT R17 | R11 |
| 1000mV | mV R16 | R9 |

*Zero adjust is on front panel

*CALIBRATION STEPS, MODELS 408A , 418A*

### 4.2.6 POWER PACK 406 AND 407

a. Connect front panel inputs the same as Trendicator rear inputs.

b. Adjust according to calibration chart. Model 407 potentiometer switch must be OFF.

c. Models 406 and 407 may be calibrated while line charging or running on batteries.

# SECTION 5

# PARTS LIST

## 5.0 INTRODUCTION

This section contains the electronic parts list for the Series 400A instruments, subdivided by circuit board assemblies. The list contains a brief description of the part, the quantity per assembly, part number, the manufacturer's name and part or identification number, and recommended spares.

The manufacturer's part number has been omitted on those parts which are easily obtained by using the description. In some cases, the part is available from several manufacturers and when this occurs, only one is listed for convenience.

All parts orders should be sent to Customer Service.

MAIN BOARD (400A), ASSEMBLY 400-4180

| REF DES | DESCRIPTION | QTY/ ASSY. | P/N | MFR | MFR'S P/N | REC SPARES |
|---|---|---|---|---|---|---|
| C1 C3 | Cap, Disc, .005 @ 1KV | 3 | 900-085-03 | Sprague | 5GA | |
| C4 C6 | Cap, Elctlt, 390 @ 15V | 3 | 910 390-15 | Sprague | 672D | 1 |
| C7 C8 | Cap, Tant, 10 @ 35V | 2 | 916-010-35 | Sprague | 196D | |
| C9 C11 | Cap, Tant, 2.2 @ 35V | 3 | 916-220-04 | Sprague | 196D | |
| C12, C13 | Cap, Disc, 100PF @ 1KV | 3 | 901-011-01 | Sprague | 5GA | |
| C14 | Cap, Polyc, .22 @ 100V | 1 | 911-032-24 | Sprague | BA2B | |
| C15 | Cap, Polyc, 2 @ 100V | 1 | 911-032-05 | Sprague | BA2B | |
| C16 | Cap, Disc 33 PF @ 1KV | 1 | 901-013-30 | Sprague | 5GA | |
| C17 | Cap, Disc .01 @ 500V | 3 | 900-021-04 | Sprague | 5GA | |
| C18 | Cap, Disc, 100PF | 1 | 915-031-01 | Sprague | DM15 | |
| C20 C21 | Cap, Disc, .02 @ 500V | 2 | 900 082-02 | Sprague | 5GA | |
| C22 | Cap, Disc, 100PF @ 1KV | | 901-011-01 | Sprague | 5GA | |
| C23 | Cap, Mica, 3PF | 1 | 915-030-30 | Sprague | DM 15 | |
| C24 | Cap, Mica, 220PF | 1 | 915-032-21 | Sprague | DM15 | |
| C25 C26 | Cap, Disc, .01 @ 500V | | 900-021-04 | Sprague | 5GA | |
| CR1 | Diode, 6.4V Zener | 1 | 961 457-70 | Siemens | 1N4577 | |
| DS1 DS4 | Display, 7-segment Led | 4 | 968-081-00 | Litronix | DL 750 | |

**MAIN BOARD (400A), ASSEMBLY 400-4180 (Continued)**

| REF. DES. | DESCRIPTION | QTY/ ASSY. | P/N | MFR | MFR'S P/N | REC SPARES |
|---|---|---|---|---|---|---|
| J3 | IC Socket, 24 DIP | 1 | 992-010-70 | Cambion | 7033790010316 | |
| P1 | Housing, AC Receptacle | 1 | 400-2490-00 | Doric | | |
| P1 | Ground Pin, AC Receptacle | 1 | 400-2500-01 | Doric | | |
| P1 | Power Pin, AC Receptacle | 2 | 400-2510-01 | Doric | | |
| P2 | Connector, PC7M | 1 | 973-380-00 | Berg | 65521-107 | |
| P2 | Connector, PC7M | 1 | 973-380-01 | Berg | 65524-107 | |
| Q1 | Transistor, PNPA152 | 1 | 964-040-55 | Motorola | MPS U55 | 1 |
| Q2 | Transistor, NPNA152 | 1 | 964-040-05 | Motorola | MPS U05 | 1 |
| Q3 | Transmistor, Selected | 1 | 220-7200-01 | Sprague | 2N3393 | 1 |
| Q4 Q5 | Transistor, PNPA | 3 | 962-425-00 | National | 2N4250 | 1 |
| Q6 Q7 | FET, N-Channel | 2 | 100-722-02 | Teledyne | U1742C | 1 |
| Q8 | Transistor, PNPA | | 962-425-00 | National | 2N4250 | |
| Q9 Q15 | Transistor, NPNA/DR492 | 7 | 964-040-03 | Motorola | MPSA13 | 1 |
| Q16 | Transistor, NPNA | 1 | 964-040-97 | Texas Inst. | TIS97 | 1 |
| R1 R2 | Res, 1/4W 5% 10 | 2 | 942-201-00 | Allen Bradley | RCR07 | |
| R3 | Res, 1/4W 5% 4.7 | 2 | 942-204-79 | Allen Bradley | RCR07 | |
| R4 | Res, 1/4W 5% 1K | 3 | 942 201-02 | Allen Bradley | RCR07 | |
| R5 | Res, 1/4W 5% 10K | 4 | 942-201-03 | Allen Bradley | RCR07 | |
| R6 | Res, 1/4W 5% 1M | 2 | 942 201-05 | Allen Bradley | RCR07 | |
| R7 | Res, 1/4W 5% 10K | | 942-201-03 | Allen Bradley | RCR07 | |
| R8 | Res, 1/4W 5% 1K | | 942 201-02 | Allen Bradley | RCR07 | |
| R9 | Res, 1/4W 5% 4.7 | | 942-204-79 | Allen Bradley | RCR07 | |
| R10, R11 | Res, 10K, 0.1% | 2 | 922-410-02 | Dale | CMF-60C | |
| R12 | Res, 3.65K, 1% | 1 | 920-436-51 | Dale | CMF-60C | |
| R13 | Pot, 500 Cermet | 1 | 960-015-07 | Beckman | 72XL | 1 |
| R14 | Pot, 200K Cermet | 1 | 960-012-09 | Beckman | 89P | 1 |
| R15 | Res, 2W, 5% 10K | 1 | 942-501-03 | Allen Bradley | RCR07 | |
| R16 | Res, 1/4W 5% 220K | 2 | 942-202-24 | Allen Bradley | | |
| R17 | Res, 1/4W 5% 22 | 1 | 942-202-20 | Allen Bradley | | |
| R18 | Res, 1/4W 5% 2.2M | 2 | 942-202-25 | Allen Bradley | RCR07 | |
| R19 | Pot, 100K Cermet | 2 | 960-011-18 | Beckman | 72XL | 1 |
| R20 | Res, 1K, 1% | 1 | 920-410-01 | Dale | CMF 60C | |
| R21 | Res, 1/4W 5% 1M | | 942-201-05 | Allen Bradley | RCR07 | |
| R22 | Pot, 100K Cermet | | 960-011-18 | Beckman | 72XL | |
| R23 | Res, 56.2K, 1% | 1 | 920-456-22 | Dale | CMF-60C | |
| R24 | Res, 1/4W 5% 100K | 5 | 942 201-04 | Allen Bradley | RCR07 | |
| R25 | Res, 1.96M, 1% | 1 | 921 419-64 | Dale | HMF-1/4, T-2 | |
| R29 | Pot, 10K Cermet | 1 | 960-011 16 | Beckman | 72XL | 1 |
| R30 | Res, 1/4W 5% 22K | 1 | 942-202-23 | Allen Bradley | RCR07 | |
| R31 | Res, 1/4W 5% 220K | | 942 202-24 | Allen Bradley | RCR07 | |
| R32 | Res, 1/4W 5% 2.2M | | 942 202-25 | Allen Bradley | RCR07 | |
| R33 | Res, 953K, 1% | 1 | 921-495-33 | Dale | CMF65C | |
| R34 | Res, 1/4W 5% 100K | | 942 201-04 | Allen Bradley | RCR07 | |
| R35 | Res, 1/4W 5% 100 | 1 | 942-201-01 | Allen Bradley | RCR07 | |
| R36 | Res, 1/4W 5% 100K | | 942-201-04 | Allen Bradley | RCR07 | |
| R37 | Res, 1/4W 5% 1K | | 942-201-02 | Allen Bradley | RCR07 | |
| R38 | Pot, 2K Cermet | 1 | 960-012-08 | Beckman | 72XL | 1 |
| R39 | Res, 1/4W 1% 9.53K | 1 | 920-495-31 | Dale | RN60C | |
| R40 | Res, 1/4W 5% 15M | 1 | 942-201-56 | Allen Bradley | RCR07 | |
| R41 | Res, 1/4W 5% 4.7M | 1 | 942-204-75 | Allen Bradley | RCR07 | |
| R42 | Res, 1/4W 5% 100K | | 942-201-04 | Allen Bradley | RCR07 | |
| R43 | Res, 1/4W 5% 100K | | 942-201-04 | Allen Bradley | RCR07 | |
| R44 | Pot, 50K Cermet | 1 | 960-015-04 | Beckman | 89P | 1 |
| R45 | Pot, 100K Cermet | 1 | 960-011-09 | Beckman | 89P | 1 |
| R46, R47 | Res, 1/4W 5% 10K | | 942-201-03 | Allen Bradley | RCR07 | |

MAIN BOARD (400A), ASSEMBLY 400-4180 (Continued)

| REF. DES. | DESCRIPTION | QTY/ ASSY. | P/N | MFR | MFR'S P/N | REC SPARES |
|---|---|---|---|---|---|---|
| S2 | Switch, 6-pole DIP | 1 | 969-050-00 | SAE | 1006-6\2 | 1 |
| T1 | Transformer, Power | 1 | 400-7040-00 | Doric | | 1 |
| TB1 | Terminal Strip | 1 | 973-010-37 | Reed Dev. | 6PCR04-002 | |
| Z1 | IC, Graded 4016 | 2 | 000-7700-00 | Doric | | 1 |
| Z2 | IC, Op. Amp. | 2 | 965-590-01 | National | 308 | 1 |
| Z3 | IC, Graded 4016 | | 000-7700-00 | Doric | | |
| Z4 | IC, Op. Amp. | | 965-590-01 | National | 308 | |
| Z5, Z6 | IC, Op. Amp. | 2 | 965-592-01 | National | 301A | 1 |
| Z7 | IC, Inv, NOR, NAND | 1 | 965-618-00 | Motorola | 4572 | 1 |
| Z8 | IC, Op. Amp, Dual | 1 | 965-617-00 | National | 358 | 1 |
| Z9 | IC, PMOS LSI | 1 | 000-7500-00* | Doric | *or 000-7501-00 | 1 |
| Z10 | IC, Hex Driver | 1 | 965-619-00 | National | 75494 | 1 |
| Z11 | Resistor Network | 1 | 400-7030-00 | Doric | | |
| Z12 | Rectifier Bridge | 1 | 966-002-26 | Gen. Inst. | WL005M | 1 |
| | IC Socet, 40 DIP | 1 | 992-010-18 | Circuit Assy. | 405-105D | |
| | Cable, Flat | 1 | 993-100-00 | Ansley | FSN-23A-18 | |

MAIN BOARD (410A), ASSEMBLY 400-4190

| REF. DES. | DESCRIPTION | QTY/ ASSY. | P/N | MFR | MFR'S P/N | REC SPARES |
|---|---|---|---|---|---|---|
| C1-C3 | Cap, Disc, .005 @ 1KV | 3 | 900-085-03 | Sprague | 5GA | |
| C4-C6 | Cap, Elctlt, 390 @ 15V | 3 | 910-390-15 | Sprague | 672D | 1 |
| C7, C8 | Cap, Tant, 10 @ 35V | 2 | 916-010-35 | Sprague | 196D | |
| C9-C11 | Cap, Tant, 2.2 @ 35V | 3 | 916-220-04 | Sprague | 196D | |
| C12, C13 | Cap, Disc, 100PF @ 1KV | 2 | 901-011-01 | Sprague | 5GA | |
| C14 | Cap, Polyc, .22 @ 100V | 1 | 911-032-24 | Sprague | BA2B | |
| C15 | Cap, Polyc, 2 @ 100V | 1 | 911-032-05 | Sprague | BA2B | |
| C16 | Cap, Mica, 3PF | 1 | 915-030-30 | Sprague | DM15 | |
| C17 | Cap, Disc, .01 @ 500V | 3 | 900-021-04 | Sprague | 5GA | |
| C18 | Cap, Disc, 100PF | 1 | 915-031-01 | Sprague | DM15 | |
| C20, C21 | Cap, Disc, .02 @ 500V | 2 | 900-082-02 | Sprague | 5GA | |
| C24 | Cap, Mica, 220PF | 1 | 915-032-21 | Sprague | DM15 | |
| C25, C26 | Cap, Disc, .01 @ 500V | | 900-021-04 | Sprague | 5GA | |
| CR1 | Diode, 6.4V, Zener | 1 | 961-457-70 | Siemens | 1N4577 | |
| DS1-DS5 | Display, 7-Segment | 5 | 968-081-00 | Litronix | DL-750 | |
| J3 | IC Socket, 24 DIP | 1 | 992-010-70 | Cambion | 7033790010316 | |
| P1 | Housing, AC Receptacle | 1 | 400-2490-01 | Doric | | |
| P1 | Ground Pin, AC Receptacle | 1 | 400-2500-01 | Doric | | |
| P1 | Power Pin, AC Receptacle | 2 | 400-2510-01 | Doric | | |
| P2 | Connectnr, PC7M | 1 | 973-380-00 | Berg | 65521-107 | |
| P2 | Connector, PC7M | 1 | 973-380-01 | Berg | 65524-107 | |
| Q1 | Transistor, PNPA152 | 1 | 964-040-55 | Motorola | MPSU55 | 1 |
| Q2 | Transistor, NPNA152 | 1 | 964-040-05 | Motorola | MPSU05 | 1 |
| Q3 | Transistor, Selected | 1 | 220-7200-01 | Sprague | 2N3393 | 1 |
| Q4, Q5 | Transistor, PNPA | 3 | 962-425-00 | National | 2N4250 | 1 |
| Q6, Q7 | FET, N-Channel | 2 | 100-722-02 | Teledyne | U1742C | 1 |
| Q8 | Transistor, PNPA | | 962-425-00 | National | 2N4250 | |
| Q9-Q15 | Transistor, NPNA, DR492 | 7 | 964 040 03 | Motorola | MPSA13 | 1 |
| Q16 | Transistor, NPNA | 1 | 964-040-97 | Texas Inst. | TIS97 | 1 |
| R1, R2 | Res, 1/4W 5% 10 | 2 | 942-201-00 | Allen Bradley | RCR07 | |
| R3 | Res, 1/4W 5% 4.7 | 2 | 942-204-79 | Allen Bradley | RCR07 | |
| R4 | Res, 1/4W 5% 1K | 3 | 942-201-02 | Allen Bradley | RCR07 | |
| R5 | Res, 1/4W 5%, 10K | 4 | 942 201 03 | Allen Bradley | RCR07 | |

MAIN BOARD (410A), ASSEMBLY 400-4190 (Continued)

| REF DES. | DESCRIPTION | QTY/ ASSY. | P/N | MFR | MFR'S P/N | REC SPARES |
|---|---|---|---|---|---|---|
| R6 | Res, 1/4W 5% 1M | 2 | 942 201-05 | Allen Bradley | RCR07 | |
| R7 | Res, 1/4W 5% 10K | | 942-201-03 | Allen Bradley | RCR07 | |
| R8 | Res, 1/4W 5% 1K | | 942-201-02 | Allen Bradley | RCR07 | |
| R9 | Res, 1/4W 5% 4.7 | | 942-204-79 | Allen Bradley | RCR07 | |
| R10, R11 | Res, WW, 10K | 2 | 934-211-75 | Elliot | Type 31 | |
| R12 | Res, 3.65K, 1% | 1 | 920-436-51 | Dale | CMF60C | |
| R13 | Pot 500 Cermet | 2 | 960-015-07 | Beckman | 72XL | 1 |
| R14 | Pot, 100K Cermet | 1 | 960-011-09 | Beckman | 89P | 1 |
| R15 | Res, 2W, 5% 10K | 1 | 942 501-03 | Allen Bradley | RCR07 | |
| R16 | Res, 1/4W 5% 220K | 2 | 942-202-24 | Allen Bradley | RCR07 | |
| R17 | Res, 1/4W 5% 22 | 1 | 942-202-20 | Allen Bradley | RCR07 | |
| R18 | Res, 1/4W 5% 2.2M | 2 | 942 202-25 | Allen Bradley | RCR07 | |
| R19 | Pot, 100K Cermet | 2 | 960-011-18 | Beckman | 72XL | 1 |
| R20 | Res, WW, 1K | 1 | 934-211-74 | Elliot | Type 31 | |
| R21 | Res, 1/4W 5% 1M | | 942-201-05 | Allen Bradley | RCR07 | |
| R22 | Pot, 100K Cermet | | 960-011-18 | Beckman | 72XL | |
| R23 | Res, WW 56.25K | 1 | 937-201-14 | Elliot | Type 31 | |
| R24 | Res, 1/4W 5% 100K | 4 | 942-201-04 | Allen Bradley | RCR07 | |
| R25 | Res, 2.02M 1% | 1 | 921-420-24 | Dale | HMF-1/4, T2 | |
| R26 | Res, 1/4W 5% 22M | 1 | 942-202-26 | Allen Bradley | RCR07 | |
| R27 | Res, 1/4W 5% 10M | 1 | 942-201-06 | Allen Bradley | RCR07 | |
| R28 | Pot, 500 Cermet | | 960-015-07 | Beckman | 72XL | |
| R29 | Pot, 10K Cermet | 1 | 960-011-16 | Beckman | 72XL | 1 |
| R30 | Res, 1/4W 5% 22K | 1 | 942-202-23 | Allen Bradley | RCR07 | |
| R31 | Res, 1/4W 5% 220K | | 942-202-24 | Allen Bradley | RCR07 | |
| R32 | Res, 1/4W 5% 2.2M | | 942-202-25 | Allen Bradley | RCR07 | |
| R33 | Res, WW, 990.75K | 1 | 937-201-13 | Elliot | Type 31 | |
| R34 | Res, 1/4W 5% 100K | | 942-201-04 | Allen Bradley | RCR07 | |
| R35 | Res, 1/4W 5% 100 | 1 | 942-201-01 | Allen Bradley | RCR07 | |
| R36 | Res, 1/4W 5% 390K | 1 | 942-203-94 | Allen Bradley | RCR07 | |
| R37 | Res, 1/4W 5% 1K | | 942-201-02 | Allen Bradley | RCR07 | |
| R38 | Pot, 2K Cermet | 1 | 960-012-08 | Beckman | 72XL | 1 |
| R39 | Res, 1/4W 1% 9.53K | 1 | 920-495-31 | Dale | RN60C | |
| R40 | Res, 1/4W 5% 15M | 1 | 942-201-56 | Allen Bradley | RCR07 | |
| R41 | Res, 1/4W 5% 4.7M | 1 | 942-204-75 | Allen Bradley | RCR07 | |
| R42, R43 | Res, 1/4W 5% 100K | | 942-201-04 | Allen Bradley | RCR07 | |
| R44 | Pot, 50K Cermet | 1 | 960-015-04 | Beckman | 89P | 1 |
| R45 | Pot, 25K Cermet | 1 | 960-012-53 | Beckman | 89P | 1 |
| R46, R47 | Res, 1/4W 5% 10K | | 942 201-03 | Allen Bradley | RCR07 | |
| S2 | Switch, 6 Pole DIP | 1 | 969-050-00 | SAE | 1006-692 | 1 |
| T1 | Transformer, Power | 1 | 400-7040-00 | Doric | | 1 |
| TB1 | Terminal Strip | 1 | 973-010-37 | Reed Dev. | 6PCR04-002 | |
| Z1 | IC, Graded 4016 | 2 | 000-7700-00 | Doric | Special | 1 |
| Z2 | Graded 308, Op Amp. | 1 | 000-7780-00 | Doric | Special | 1 |
| Z3 | IC, Graded 4016 | | 000 7700-00 | Doric | Special | |
| Z4, Z5 | IC, Op. Amp. | 2 | 965-616-00 | National | 356 | 1 |
| Z6 | IC, Op. Amp. | 1 | 965-592-01 | National | 301A | 1 |
| Z7 | IC, Inv, NOR, NAND | 1 | 965-618-00 | Motorola | 4572 | 1 |
| Z8 | IC, Op. Amp., Dual | 1 | 965-617-00 | National | 358 | 1 |
| Z9 | IC, PMOS LSI | 1 | 000-7500-00 or 000-7501 00 | Doric | Special | 1 |
| Z10 | IC, Hex Driver | 1 | 965 619-00 | National | 75494 | 1 |
| Z11 | Resistor Network | 1 | 400-7030-00 | Doric | | |
| Z12 | Rectifier Bridge | 1 | 966 002-26 | Gen. Inst. | WL005M | 1 |
| | IC Socket, 40 DIP | 1 | 992-010-18 | Circuit Assy. | 405-105D | |
| | Cable, Flat | 1 | 993-100-00 | Ansley | FSN 23A-18 | |

POWER PACK POTENTIOMETER, ASSEMBLY 407-4100

| REF. DES | DESCRIPTION | QTY/ ASSY | P/N | MFR | MFR'S P/N | REC SPARES |
|---|---|---|---|---|---|---|
| C1, C2 | Cap, Elctlt. 390 *w* 15V | 2 | 910-390-15 | Sprague | 672D | 1 |
| C3 | Cap, Elctlt. 270 *w* 40V | 1 | 910-270-40 | Sprague | 672D | 1 |
| C4 | Cap, Disc. .01 *w* 500V | 1 | 900-021-04 | Sprague | 5GA | |
| C5-C7 | Cap, Tant 47 *w* 20V | 3 | 916-471-20 | Sprague | 196D | |
| CR1 | Rectifier Bridge | 1 | 966-002-26 | Gen. Inst. | WL005M | 1 |
| CR2-CR7 | Rectifier, 200V | 6 | 966-002-00 | Diodes, Inc. | SD-2 | 2 |
| CR8 | LED, Red | 1 | 968-010-10 | Dialco | 550-01-03 | 1 |
| CR9 | Diode, 7.5V | 1 | 961-523-62 | Diodes, Inc. | 1N5236B | 1 |
| Q1 | Transistor, NPNSH106 | 1 | 962-364-60 | Motorola | 2N3646 | 1 |
| Q2 | Transistor, PNPA | 1 | 962-423-08 | National | 2N4250 | 1 |
| Q3 | Transistor, NPNA98-5 | 2 | 962-339-30 | Sprague | 2N3393 | 1 |
| Q4 | Transistor, PNPA152 | 1 | 964-040-55 | Motorola | MPSU55 | 1 |
| Q5 | Transistor, NPNA98-5 | | 962-339-30 | Sprague | 2N3393 | |
| R1 | Res, 5.11K, 1% | 1 | 920-451-11 | Dale | CMF60C | |
| R2 | Res, 6.34K, 1% | 1 | 920-463-41 | Dale | CMF60C | |
| R3 | Pot, 2K Cermet | 1 | 960-012-08 | Beckman | 72XL | 1 |
| R4 | Res, 1/4W 5% 1M | 2 | 942-201-05 | Allen Bradley | | |
| R5 | Res, 1/4W 5% 4.7M | 2 | 942-204-75 | Allen Bradley | RCR07 | |
| R6 | Res, 1/4W 5% 30K | 1 | 942-203-03 | Allen Bradley | RCR07 | |
| R7 | Res, 1/4W 5% 680 | 1 | 942-206-81 | Allen Bradley | RCR07 | |
| R8 | Res, 1K, 1% | 1 | 920-410-01 | Dale | CMF60C | |
| R9 | Res, 2.49K | 1 | 920-424-91 | Dale | CMF60C | |
| R10 | Pot, 10K WW | 1 | 960-011-21 | Amp | 4201B103 | 1 |
| R11 | Res, 5.49K | 1 | 920-454-91 | Dale | CMF60C | |
| R12/SW2 | Pot/Switch, 100K | 1 | 960-011-20 | Allen Bradley | SERIES 70 | 1 |
| R13 | Res, 1/4W 5% 4.7M | | 942-204-75 | Allen Bradley | RCR07 | |
| R14 | Res, 490, 1% | 1 | 920-349-00 | Dale | CMF60C | |
| R15 | Res, 10, 1% | 1 | 920-310-09 | Dale | CMF60C | |
| R16 | Res, 20K, 1% | 2 | 920-420-02 | Dale | CMF60C | |
| R17 | Res, 499, 1% | 1 | 920-449-90 | Dale | CMF60C | |
| R18 | Res, 20K, 1% | | 920-420-02 | Dale | CMF60C | |
| R19 | Res, 1/4W 5% 100K | 2 | 942-201-04 | Allen Bradley | | |
| R20 | Pot, 100K Cermet | | 960-011-16 | Beckman | | |
| R21 | Res, 1/4W 5% 680K | 1 | 942-206-84 | Allen Bradley | | |
| R22 | Res, 1/4W 5% 1K | 2 | 942-201-02 | Allen Bradley | | |
| R23 | Res, 1/4W 5% | 1 | 942-201-03 | Allen Bradley | | |
| R24 | Res, 1/4W 5% 100K | | 942-201-04 | Allen Bradley | | |
| R25 | Res, 1/4W 5% 330 | 1 | 942-203-31 | Allen Bradley | | |
| R26 | Res, 1/4W 5% 1K | | 942-201-02 | Allen Bradley | | |
| R27 | Res, 1/4W 5% 1M | | 942-201-05 | Allen Bradley | | |
| SW1 | Switch, Rocker | 1 | 969-020-00 | C & K | 7101J-1V5B | 1 |
| SW2 | See R12 | | | | | |
| Z1 | IC, Quad Op. Amp. | 1 | 965-599-00 | National | 324 | 1 |
| Z2 | IC, Hex Inverter | 1 | 965-587-05 | National | 4069 | 1 |
| Z3 | Regulator | 1 | 965-620-00 | Fairchild | 78MGT2C | 1 |
| | Battery Assembly | 1 | 407-4200 02 | Doric | | 1 |

MULTIRANGE BOARD, ASSEMBLY 400-4450

| REF. DES. | DESCRIPTION | QTY/ ASSY. | P/N | MFR | MFR'S P/N | REC SPARES |
|---|---|---|---|---|---|---|
| C1 | Cap, Disc 220PF @ 1KV | 1 | 901-012-21 | Sprague | 5GA | |
| CR1-CR11 | Diode | 11 | 961-091-40 | Teledyne | 1N4148 | 2 |
| R1 | Res, WW 20K | 1 | 934-212-03 | Elliot | Type 31 | |
| R2 | Pot, 200 Cermet | 3 | 960-012-04 | Beckman | 72XL | 1 |
| R3 | Res, WW, 25.834K | 1 | 934-202-06 | Elliot | Type 31 | |
| R4 | Pot, 200 Cermet | | 960-012-04 | Beckman | 72XL | |
| R5 | Res, WW, 25.696K | 1 | 934-202-05 | Elliot | Type 31 | |

MULTIRANGE BOARD, ASSEMBLY 400-4450 (Continued)

| REF. DES. | DESCRIPTION | QTY/ ASSY. | P/N | MFR | MFR'S P/N | REC SPARES |
|---|---|---|---|---|---|---|
| R6 | Pot, 200 Cermet | | 960-012-04 | Beckman | 72XL | |
| R7 | Res, WW, 181 972K | 1 | 934-202 02 | Elliot | Type 31 | |
| R8 | Pot, 2K Cermet | 3 | 960 012-08 | Beckman | 72XL | 1 |
| R9 | Res, WW, 180.637K | 1 | 934-202-01 | Elliot | Type 31 | |
| R10 | Pot, 2K Cermet | | 960-012-08 | Beckman | 72XL | |
| R11 | Res, WW, 187.165K | 1 | 934-202-03 | Elliot | Type 31 | |
| R12 | Pot, 2K Cermet | | 960-012-08 | Beckman | 72XL | |
| R13 | Res, 1/4W 10% 100M | 4 | 943-201-07 | Allen Bradley | RCR07 | |
| R14 | Res, 1/4W 5% 15M | 1 | 942-201-56 | Allen Bradley | | |
| R15 | Res, 1/4W 10% 100M | | 943-201-07 | Allen Bradley | | |
| R16 | Res, 13K, 1% | 1 | 920-413-02 | Dale | CMF60C | |
| R17 | Res, 20K, 1% | 1 | 920-420-02 | Dale | CMF60C | |
| R18 | Res, 117K, 1% | | 920-411-73 | Dale | CMF60C | |
| R19 | Res, 1.30M, 1% | 1 | 922-413-04 | Dale | HMF-1/8, T2 | |
| R20 | Res, 1/4W 5% 22M | 1 | 942-202-26 | Allen Bradley | RCR07 | |
| R21 | Pot, 100K Cermet | 1 | 960-011-18 | Beckman | 72XL | |
| R22, R23 | Res, 1/4W 10% 100M | | 943-201-07 | Allen Bradley | | |
| S1-S6 | Switch | 1 | 969-010-21 | Centralab | 6PB-4P-1L | 1 |
| | Engraved Button Set | 1 | 400 2290-00 | Doric | | |
| | Cable, 3 inch | 1 | 993-100-10 | Ansley | | |

POWER PACK 406, ASSEMBLY 406-4200

| REF. DES. | DESCRIPTION | QTY/ ASSY. | P/N | MFR | MFR'S P/N | REC SPARES |
|---|---|---|---|---|---|---|
| C1, C2 | Cap, Elct 390 @ 15V | 2 | 910-390-15 | Sprague | 672D | 1 |
| C3 | Cap, Elct 270 @ 40V | 1 | 910-270-40 | Sprague | 672D | 1 |
| C4 | Cap, Disc .01 @ 500V | 1 | 900-021-04 | Sprague | 5GA | |
| C5-C7 | Cap, Tant 47 @ 20V | 3 | 916-471-20 | Sprague | 196D | |
| CR1 | Rectifier Bridge | 1 | 966-002-26 | Gen. Inst. | WL005M | 1 |
| CR2-CR7 | Rectifier, 200V | 6 | 966-002-00 | Diodes, Inc. | SD-2 | 2 |
| CR8 | LED, Red. | 1 | 968-010-10 | Dialon | 550-01-03 | 1 |
| CR9 | Diode (7.5V) | 1 | 961-523-62 | Fairchild | 1N5236B | 1 |
| Q1 | Transistor | 1 | 962-364-60 | Motorola | 2N3646 | 1 |
| Q2 | Transistor | 1 | 962-425-00 | National | 2N4250 | 1 |
| Q3 | Transistor, NPNA98-5 | 2 | 962-339-30 | Sprague | 2N3393 | 1 |
| Q4 | Transistor, PNPA152 | 1 | 964-040-55 | Motorola | MPSU55 | 1 |
| Q5 | Transistor, NPNA98-5 | | 962-339-30 | Sprague | 2N3393 | |
| R1 | Res, 5.11K, 1% | 1 | 920-451-11 | Dale | CMF60C | |
| R2 | Res, 6.34K, 1% | 1 | 920-463-41 | Dale | CMF60C | |
| R3 | Pot, 2K Cermet | 1 | 960-012-08 | Beckman | 72XL | 1 |
| R4 | Res, 1/4W 5% 1M | 1 | 942-201-05 | Allen Bradley | RCR07 | |
| R5 | Res, 1/4W 5% 4.7M | 1 | 942-204-75 | Allen Bradley | RCR07 | |
| R6 | Res, 1/4W 5% 30K | 1 | 942-203-03 | Allen Bradley | RCR07 | |
| R7 | Res, 1/4W 5% 680 | 1 | 942-206-81 | Allen Bradley | RCR07 | |
| R19 | Res, 1/4W 5% 100K | 2 | 942-201-04 | Allen Bradley | RCR07 | |
| R20 | Pot, 100K Cermet | 1 | 960-011-18 | Beckman | 72XL | 1 |
| R21 | Res, 1/4W 5% 680K | 1 | 942-206-84 | Allen Bradley | RCR07 | |
| R22 | Res, 1/4W 5% 1K | 2 | 942-201-02 | Allen Bradley | RCR07 | |
| R23 | Res, 1/4W 5% 10K | 1 | 942-201-03 | Allen Bradley | RCR07 | |
| R24 | Res, 1/4W 5% 100K | | 942-201-04 | Allen Bradley | RCR07 | |
| R25 | Res, 1/4W 5% 330 | 1 | 942-203-31 | Allen Bradley | RCR07 | |
| R26 | Res, 1/4W 5% 1K | | 942-201-02 | Allen Bradley | RCR07 | |
| SW1 | Rocker Switch | 1 | 969-020-00 | C & K | 7101J-1V5B | 1 |
| Z1 | IC, Quad. Op. Amp. | 1 | 965-599-00 | National | 324 | 1 |
| Z2 | IC, Hex Inverter | 1 | 965-587-05 | National | 4069 | 1 |
| Z3 | Regulator | 1 | 965-620-00 | Fairchild | 78MGT2C | 1 |
| | Battery Assembly | 1 | 407-4200-02 | Doric | | 1 |

DIN MULTIRANGE BOARD, ASSEMBLY 400-4130

| RES. DES. | DESCRIPTION | QTY/ ASSY. | P/N | MFR | MFR'S P/N | REC SPARES |
|---|---|---|---|---|---|---|
| CR1-CR11 | Diode | 11 | 961-091-40 | Teledyne | 1N4148 | 2 |
| R1 | Pot, 200 Cermet | 5 | 960-012-04 | Beckman | 72XL | 1 |
| R2 | Res, WW 19.489K | 1 | 934-216-69 | Elliot | Type 31 | |
| R3 | Pot, 200 Cermet | | 960-012-04 | Beckman | 72XL | |
| R4 | Res, WW 25.834K | 1 | 934-202-06 | Elliot | Type 31 | |
| R5 | Pot, 200 Cermet | | 960-012-04 | Beckman | 72XL | |
| R6 | Res, WW 25.486K | 1 | 934-216-70 | Elliot | Type 31 | |
| R7 | Pot, 200 Cermet | | 960-012-04 | Beckman | 72XL | |
| R8 | Res, WW 16.826K | 1 | 934-216-68 | Elliot | Type 31 | |
| R9 | Pot, 10 Cermet | 1 | 960-011-19 | Beckman | 72XL | 1 |
| R10 | Res, WW 857.3 | 1 | 937-201-19 | Elliot | Type 31 | |
| R11 | Pot, 200 Cermet | | 960-012-04 | Beckman | 72XL | |
| R12 | Res, WW 31K | 1 | 937-201-18 | Elliot | Type 31 | |
| R13 | Res, WW 71.61K | 1 | 937-201-20 | Elliot | Type 31 | |
| R14 | Res, WW 71.71K | 1 | 937-201-21 | Elliot | Type 31 | |
| R15 | Pot, 50K Cermet | 1 | 960-015-08 | Beckman | 72XL | 1 |
| R16, R17 | Pot, 100K Cermet | 2 | 960-011-18 | Beckman | 72XL | 1 |
| R18 | Res, 1/4W 10% 100M | 4 | 943-201-07 | Allen Bradley | RCR07 | |
| R19 | Res, 1/4W 5% 15M | 1 | 942-201-56 | Allen Bradley | RCR07 | |
| R20 | Res, 1/4W 10% 100M | | 943 201-07 | Allen Bradley | RCR07 | |
| R21 | Res, 13K, 1% | 1 | 920-413-02 | Dale | CMF60C | |
| R22 | Res, 20K, 1% | 1 | 920-420-02 | Dale | CMF60C | |
| R23 | Res, 117K, 1% | 1 | 920-411-73 | Dale | CMF60C | |
| R24 | Res, 1.30M 1% | 1 | 922-413-04 | Dale | HMF-1/8, T2 | |
| R25 | Res, 1/4W 10% 100M | | 943-201-07 | Allen Bradley | RCR07 | |
| R26 | Res, 1/4W 5% 22M | 2 | 942-202-26 | Allen Bradley | RCR07 | |
| R27 | Res, 1.2605M, 0.1% | 1 | 922-412-64 | Dale | HMF-1/8, T2 | |
| R28 | Res, 1/4W 5% 22M | | 942-202-26 | Allen Bradley | RCR07 | |
| R29 | Res, 1/4W 10% 100M | | 943-201-07 | Allen Bradley | RCR07 | |
| S1-S6 | Switch | 1 | 969-010-24 | Centralab | PB15 | 1 |
| | Engraved Button Set | 1 | 400-2291-00 | Doric | Special | |
| | Cable, 3 inch | 1 | 993-100-10 | Ansley | | |

SWITCH ERROR INDICATOR, ASSEMBLY 400-4420

| REF. DES. | DESCRIPTION | QTY/ ASSY. | P/N | MFR | MFR'S P/N | REC SPARES |
|---|---|---|---|---|---|---|
| Q1 | Transistor, PNP | 1 | 962-425-00 | National | 2N4250 | 1 |
| Q2 | Transistor, NPN | 1 | 962-339-30 | Sprague | 2N3393 | 1 |
| R1, R2 | Res, 1/4W 5% 10K | 2 | 942-201-03 | Allen Bradley | RCR07 | |
| R3 | Res, 1/4W 5% 6.8K | 1 | 942-206-82 | Allen Bradley | RCR07 | |
| TB1 | Terminal Strip | 1 | 973-010-32 | Reed Dev. | 6PCR02-002 | |
| | Cable Assy, I/O | 1 | 400-4521-00 | Doric | Special | |

SWITCH BOARD, ASSEMBLY 400-4430

| REF. DES. | DESCRIPTION | QTY/ ASSY. | P/N | MFR | MFR'S P/N | REC SPARES |
|---|---|---|---|---|---|---|
| R1-R5 | Res, 1/4W 5% 10K | 5 | 942-201-03 | Allen Bradley | RCR07 | |
| S1-S5 | Switch | 1 | 969-010-23 | Centralab | PB15 | 1 |
| | Terminal Strip | 1 | 973-010-34 | Reed Dev. | 6RCR12-002 | |

## DATA OUTPUT BOARD, ASSEMBLY 400-4440

| REF DES | DESCRIPTION | QTY | P/N | MFR | MFR'S P/N | REC SPARES |
|---|---|---|---|---|---|---|
| C1-C3 | Cap, Tant, 2.2 @ 35V | 4 | 916-220-04 | Sprague | 196D | |
| C4 | Cap, Disc, 100 PF @ 1KV | 3 | 901-011-01 | Sprague | 5GA | |
| C5 | Cap, Tant, 47 @ 20V | 1 | 916-471-20 | Sprague | 196D | |
| C6 | Cap, Disc .01 @ 1KV | 1 | 900-021-04 | Sprague | 5GAS10 | |
| C7 | Cap, Tant, 2.2 @ 35V | | 916-220-04 | Sprague | 196D | |
| C8 | Cap, Mica, 510 PF | 1 | 915-035-11 | Sprague | DM15 | |
| C9 | Cap, Disc .005 @ 1KV | 1 | 900-085-03 | Sprague | 5GA | |
| C10 | Cap, Tant, 10 @ 35V | 1 | 916-010-35 | Sprague | 196D | |
| C11, C12 | Cap, Disc, 100 PF @ 1KV | | 901-011-01 | Sprague | 5GA | |
| CR1 | Diode, 1N457A | 1 | 961-045-70 | Teledyne | | |
| CR2-CR5 | Diode, 1N914 | 4 | 961-091-40 | Teledyne | | |
| CR6 | Diode, 1N751A | 1 | 961-075-11 | Teledyne | | |
| J1 | Connector, Cable 14F | 1 | 973-390-00 | Berg | 65043-030 | |
| Q1 | Transistor, 2N3646 | 2 | 962-364-60 | Motorola | NPNSH106 | |
| Q2 | Transistor, 2N3638 | 1 | 962-363-80 | National | PNPSH105 | |
| Q3 | Transistor, 2N3646 | | 962-364-60 | Motorola | NPNSH106 | |
| Q4 | FET, U1742C | 1 | 100-722-02 | Teledyne | | |
| Q5 | Transistor, 2N3393 | 1 | 962-339-30 | Sprague | NPNA98-5 | |
| R1, R2 | Res, 1/4 W 5% 100 | 4 | 942-201-01 | Allen Bradley | | |
| R3, R4 | Res, 1/4 W 5% 20K | 4 | 942-202-03 | Allen Bradley | | |
| R5 | Res, 1/4 W 5% 100 | | 942-201-01 | Allen Bradley | | |
| R6 | Res, 1/4 W 5% 180 | 1 | 942-201-81 | Allen Bradley | | |
| R7 | Res, 1/4W 5% 47K | 1 | 942-204-73 | Allen Bradley | | |
| R8 | Res, 1/4 W 5% 1K | 1 | 942-201-02 | Allen Bradley | | |
| R9 | Res, 1/4 W 5% 100 | | 942-201-01 | Allen Bradley | | |
| R10 | Res, 1/4 W 5% 3.9K | 1 | 942-203-92 | Allen Bradley | | |
| R11 | Res, 1/4 W 5% 510 | 1 | 942-205-11 | Allen Bradley | | |
| R12 | Pot, 10K Cermet | 1 | 960-011-16 | Beckman | 72XL | 1 |
| R13 | Res, RN60C, 7.5K | 1 | 920-475-01 | Dale | | |
| R14 | Res, 1/4 W 5% 2.2M | 1 | 942-202-25 | Allen Bradley | | |
| R15, R16 | Res, 1/4 W 5% 20K | | 942-202-03 | Allen Bradley | | |
| R17, R18 | Res, 1/4 W 5% 100K | 2 | 942-201-04 | Allen Bradley | | |
| T1 | Transformer | 1 | 967-020-10 | Pulse Eng. | 8270 | 1 |
| Z1, Z2 | IC, Optical Isolator | 2 | 965-570-00 | Hewlett-Packard | 5082-4350 | 1 |
| Z3 | IC, Hex Inverter, CMOS | 5 | 965-587-21 | Fairchild | 4049 | 1 |
| Z4 | IC, Multi-vibrator | 1 | 965-587-14 | Fairchild | 4528 | 1 |
| Z5 | IC, 4-2 IN NAND CMOS | 1 | 965-587-02 | Motorola | 4011 | 1 |
| Z6-Z8 | IC, Dual SR CMOS | 3 | 965-587-03 | Motorola | 4015 | 1 |
| Z9-Z12 | IC, Hex Inverter, CMOS | | 965-587-21 | Fairchild | 4049 | |
| Z13 | IC, Dual DFF, CMOS | 1 | 965-587-23 | Fairchild | 4013 | 1 |
| | Terminal, Female | 6 | 973-395-00 | Berg | 47712 | |
| | Mating Connector, Data Output | 1 | 973-010-40 | SAE | SCC15/DI-2 | 1 |
| | Hood, Connector | 1 | 973-010-41 | Viking | 036-0098-002 | 1 |
| | Key, Connector | 1 | 973-021-05 | SAE | 057-002-0000 | 1 |

### ANALOG PROGRAMMING MODULE CHART

| PART # | RANGE TYPE | PART # | RANGE TYPE |
|---|---|---|---|
| 400-4530-00 | J | 400-4539-00 | PT4 |
| 400-4531-00 | K | 400-4540-00 | PT3 |
| 400-4532-00 | T | 400-4541 00 | I1 |
| 400-4533-00 | R | 400-4542-00 | I2 |
| 400-4534-00 | S | 400-4543-00 | K1 |
| 400-4535-01 | B | 400-4544-00 | K2 |
| 400-4536-00 | Fe Con | 400-4545-01 | K3 |
| 400-4537-00 | Cu Con | 400-4546-01 | K4 |
| 400-4538 00 | E | | |

### MISCELLANEOUS SPARE PARTS

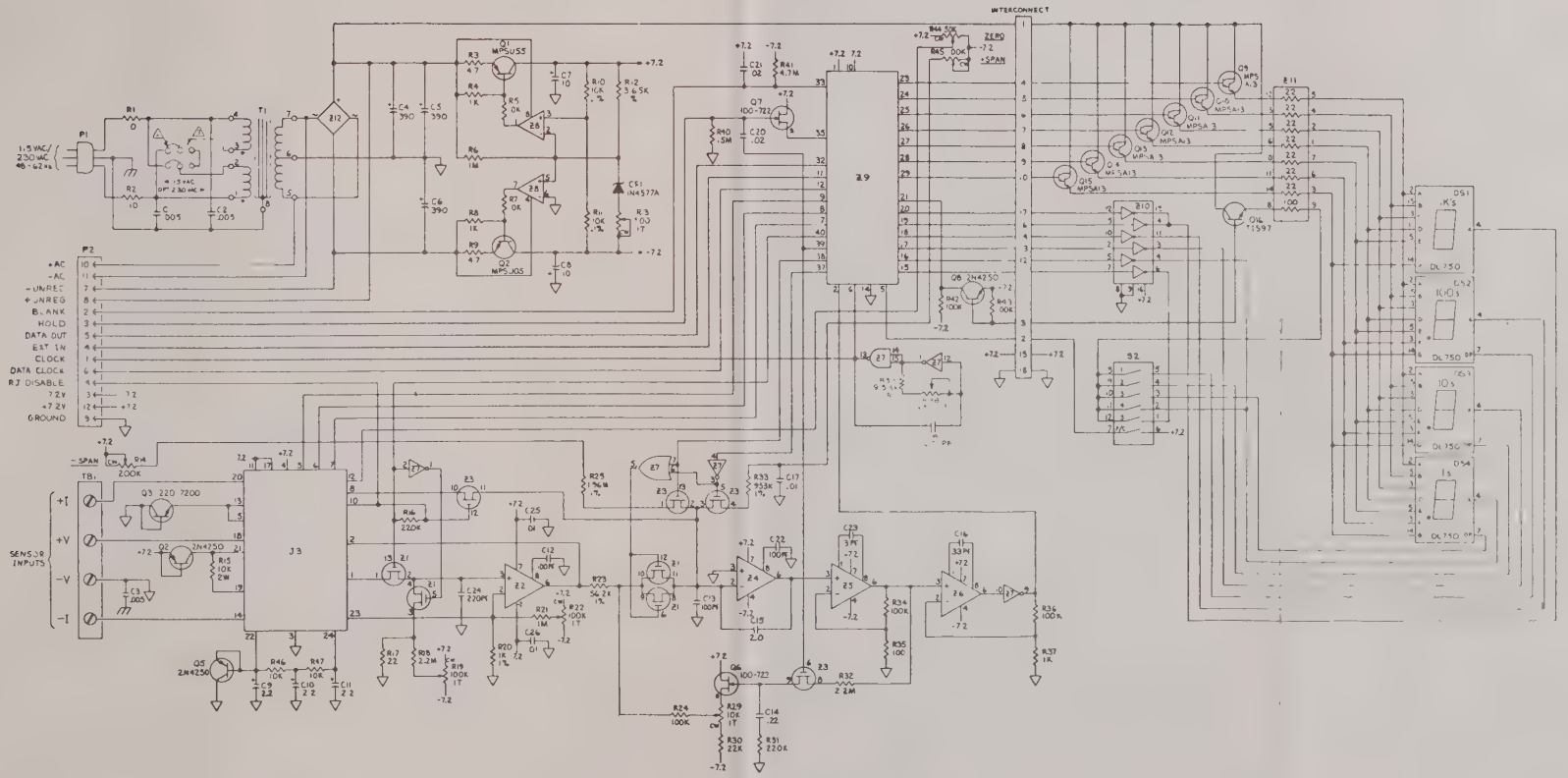
| PART # | DESCRIPTION | COMMENTS |
|---|---|---|
| 400-206X-00 | Nameplate, Front Panel | Specify range, °C or °F and # of pushbuttons |
| 400-2040-00 | Rear Panel | |
| 400-2030-02 | Front Panel, Plexiglas | |

# SECTION 6

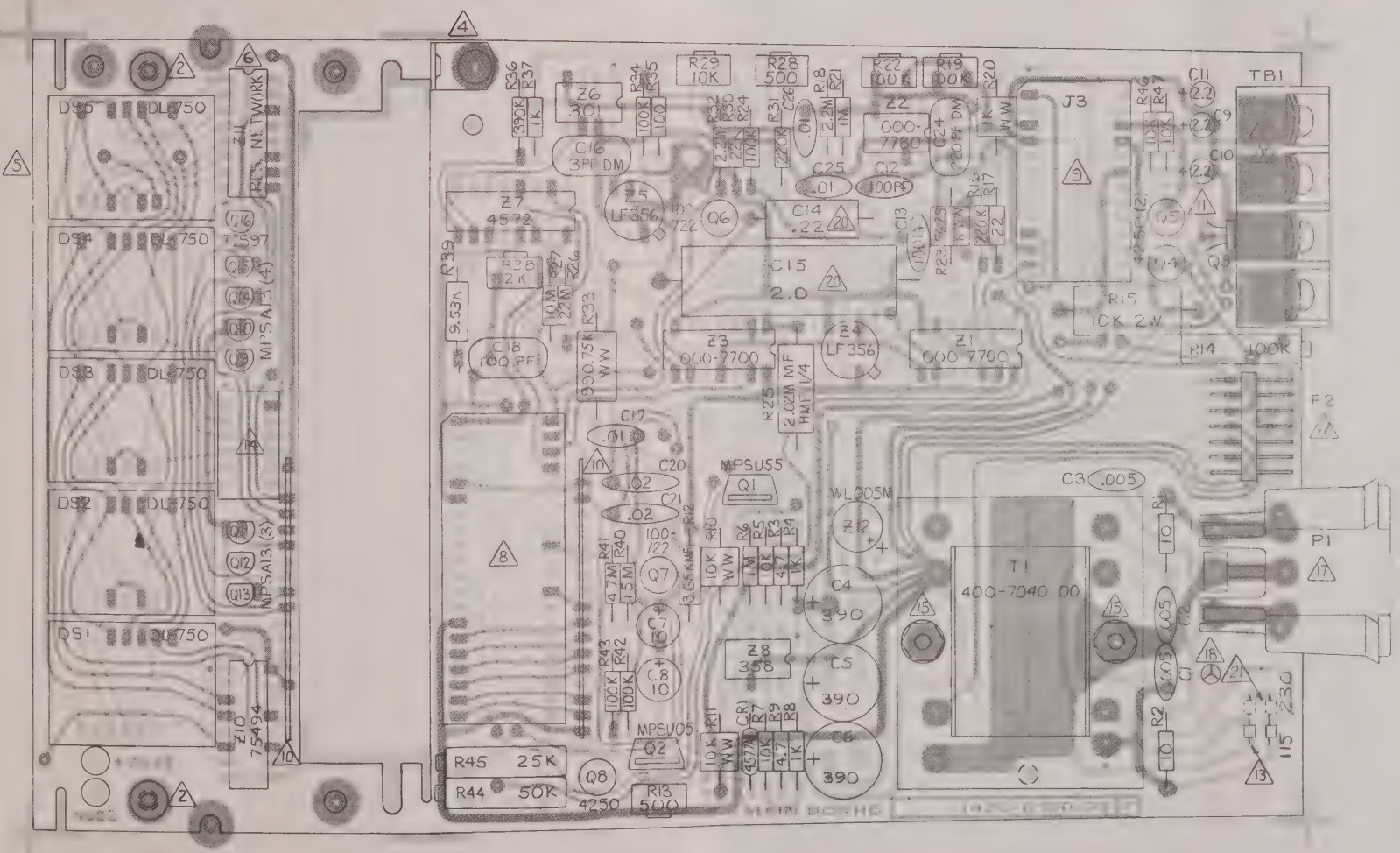
# SCHEMATICS.

| DRAWING | TITLE | TYPE* DRAWING | PAGE |
|---|---|---|---|
| 400-4180-XX | Main Board, Model 400A | A | 6-2 |
| 400-6180-XX | Main Board, Model 400A | S | 6-3 |
| 400-4190-XX | Main Board, Model 410A | A | 6-4 |
| 400-6190-XX | Main Board, Model 410A | S | 6-5 |
| 400-4130-XX | DIN Multirange Board | A | 6-6 |
| 400-6130-XX | DIN Multirange Board | S | 6-7 |
| 400-4420-XX | Switch Error Indicator Board | A | 6-8 |
| 400-6420-XX | Switch Error Indicator Board | S | 6-9 |
| 400-4430-XX | Switch Board | A | 6-10 |
| 400-6430-XX | Switch Board | S | 6-11 |
| 400-4440-XX | BCD Data Board | A | 6-12 |
| 400-6440-XX | BDC Data Board | S | 6-13 |
| 400-4450-XX | Multirange Board | A | 6-14 |
| 400-6450-XX | Multirange Board | S | 6-15 |
| 400-4580-XX | External Switching Unit | A | 6-16 |
| 400-6580-XX | External Switching Unit | S | 6-17 |
| 406-4200-XX | Power Pack, Model 406 | A | 6-18 |
| 406-6200-XX | Power Pack, Model 406 | S | 6-19 |
| 407-4100-XX | Power Pack Pot, Model 407 | A | 6-20 |
| 407-6100-XX | Power Pack Pot, Model 407 | S | 6-21 |
| 409-4100-XX | RTD Switching Unit | A | 6-22 |
| 409-6100-XX | RTD Switching Unit | S | 6-23 |
| 000-7840-XX | Dimensional Outline | O | 6-24 |

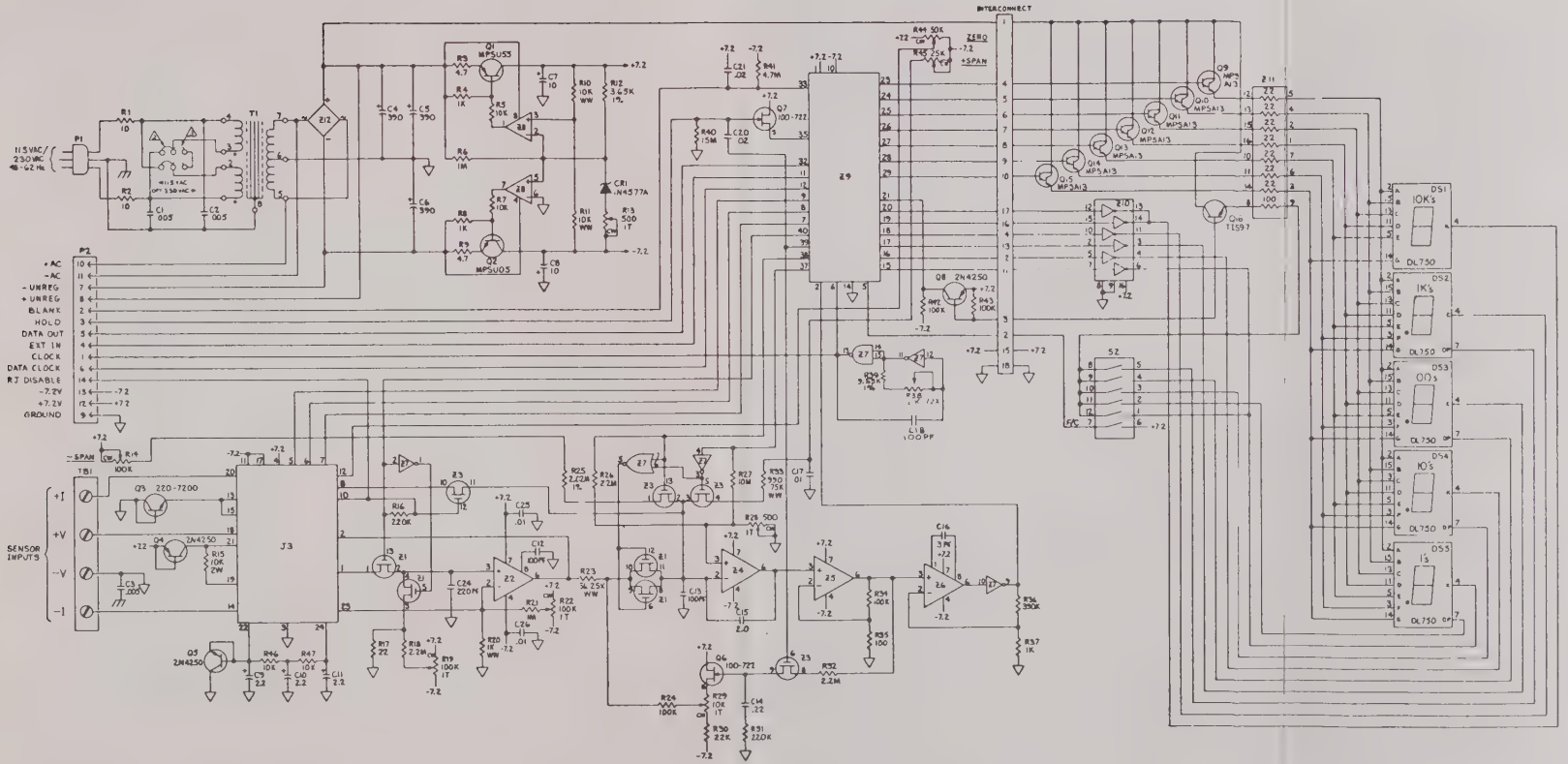
*A = Assembly S = Schematic O = Outline



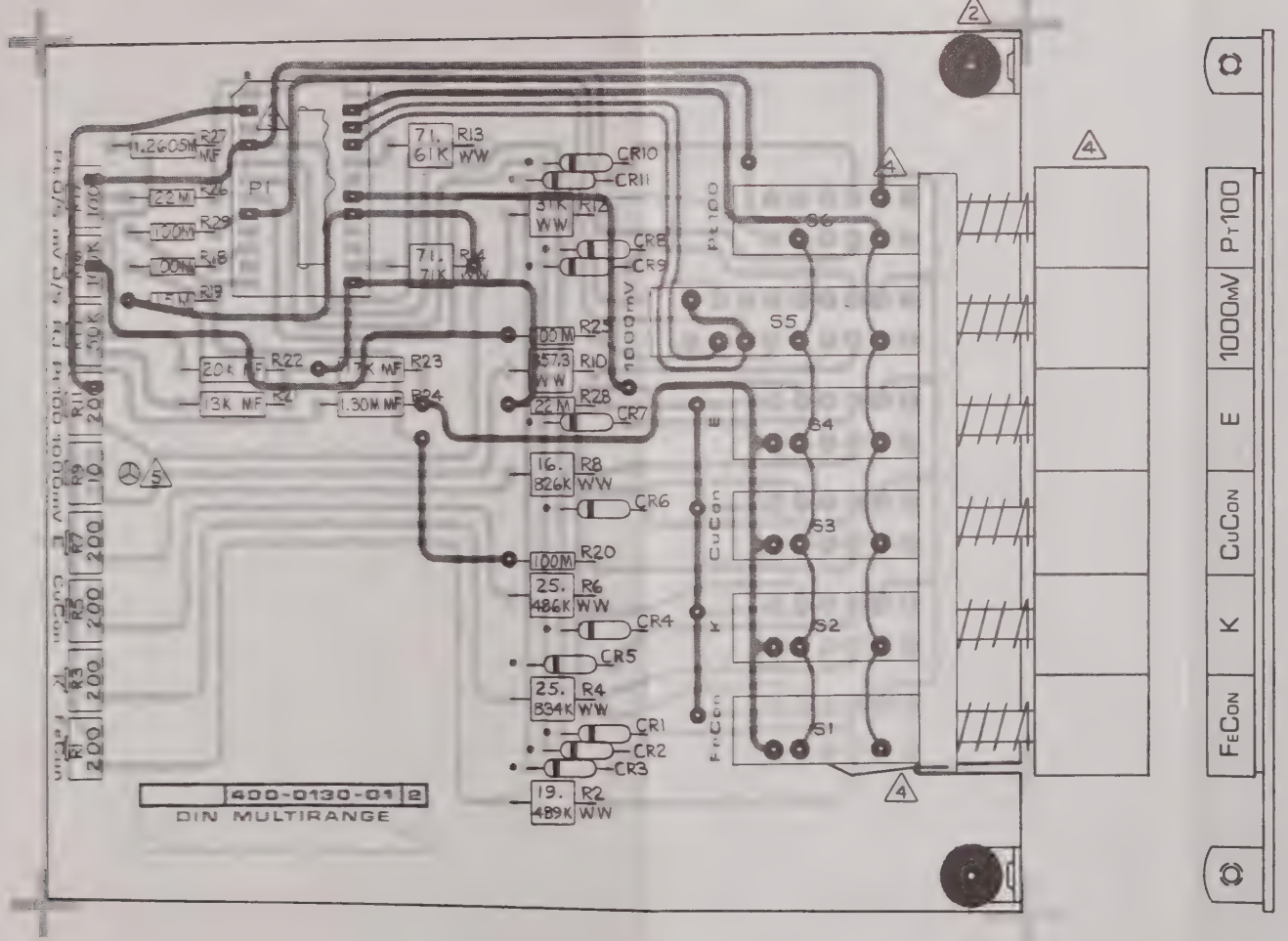

*MAIN BOARD (400A)*
*SCHEMATIC 400-6180-05*



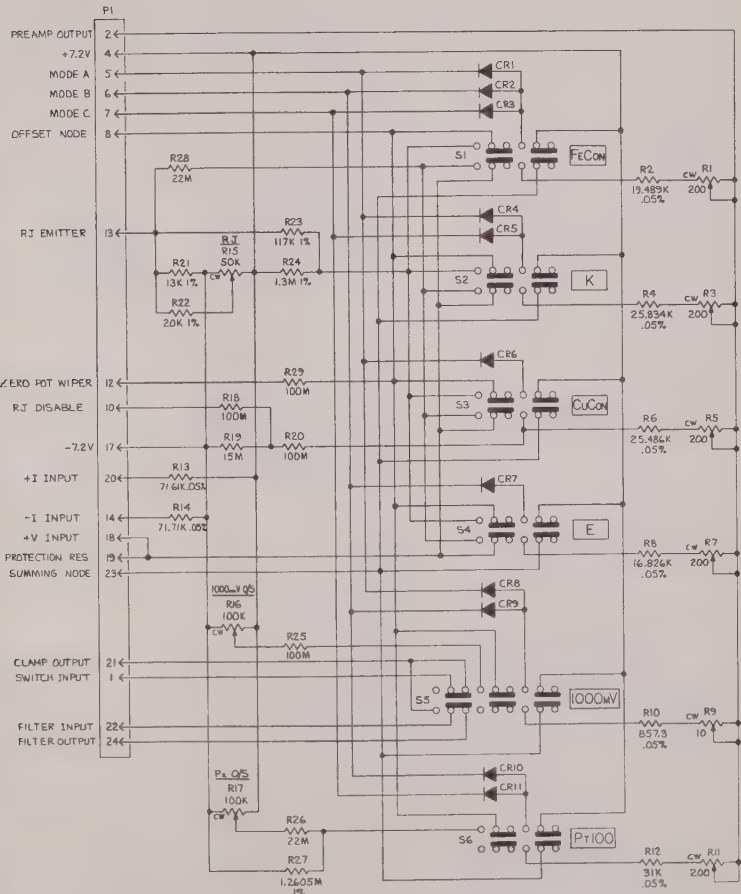

*MAIN BOARD (410A)*
*ASSEMBLY 400-4190-06*



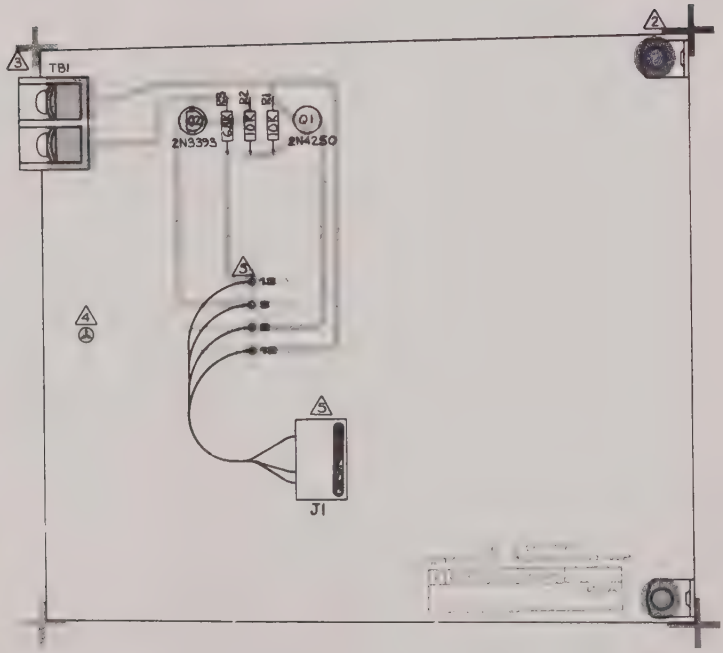

*MAIN BOARD (410A)*
*SCHEMATIC 400-6190-05*



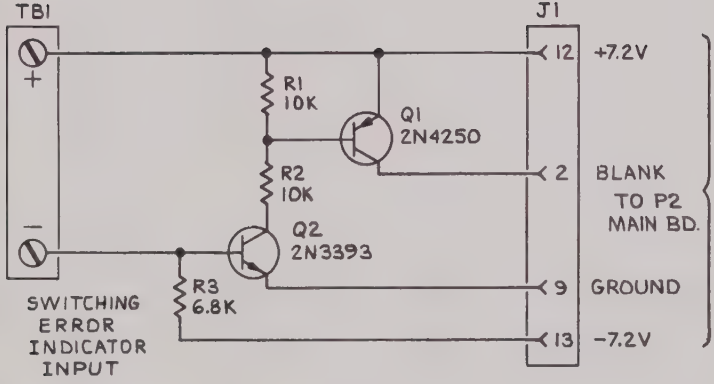

*DIN MULTIRANGE BOARD*
*ASSEMBLY 400-4130-00*



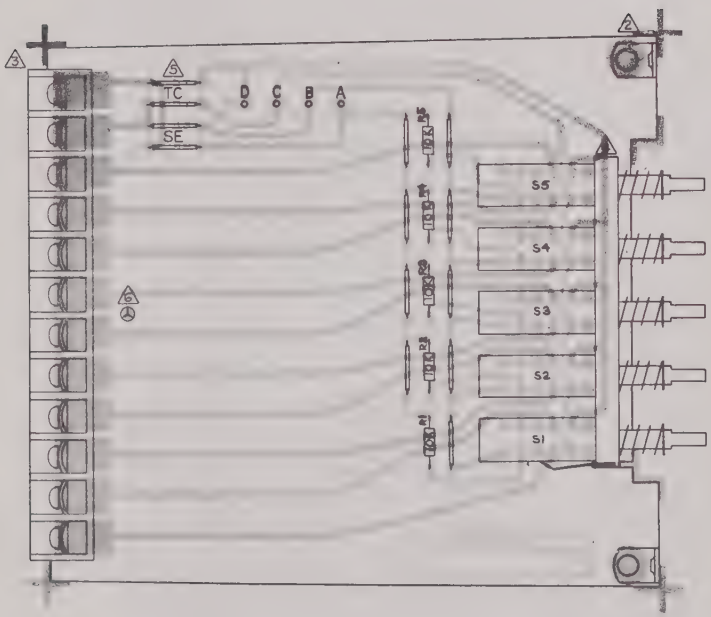

***DIN MULTIRANGE BOARD SCHEMATIC 400-6130-00***



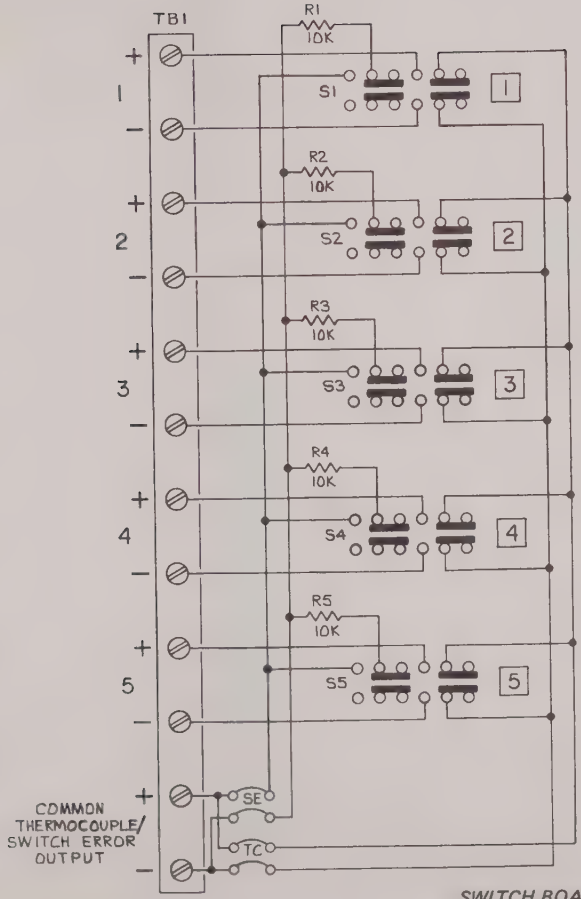

*SWITCH ERROR INDICATOR ASSEMBLY 400-4420-00*



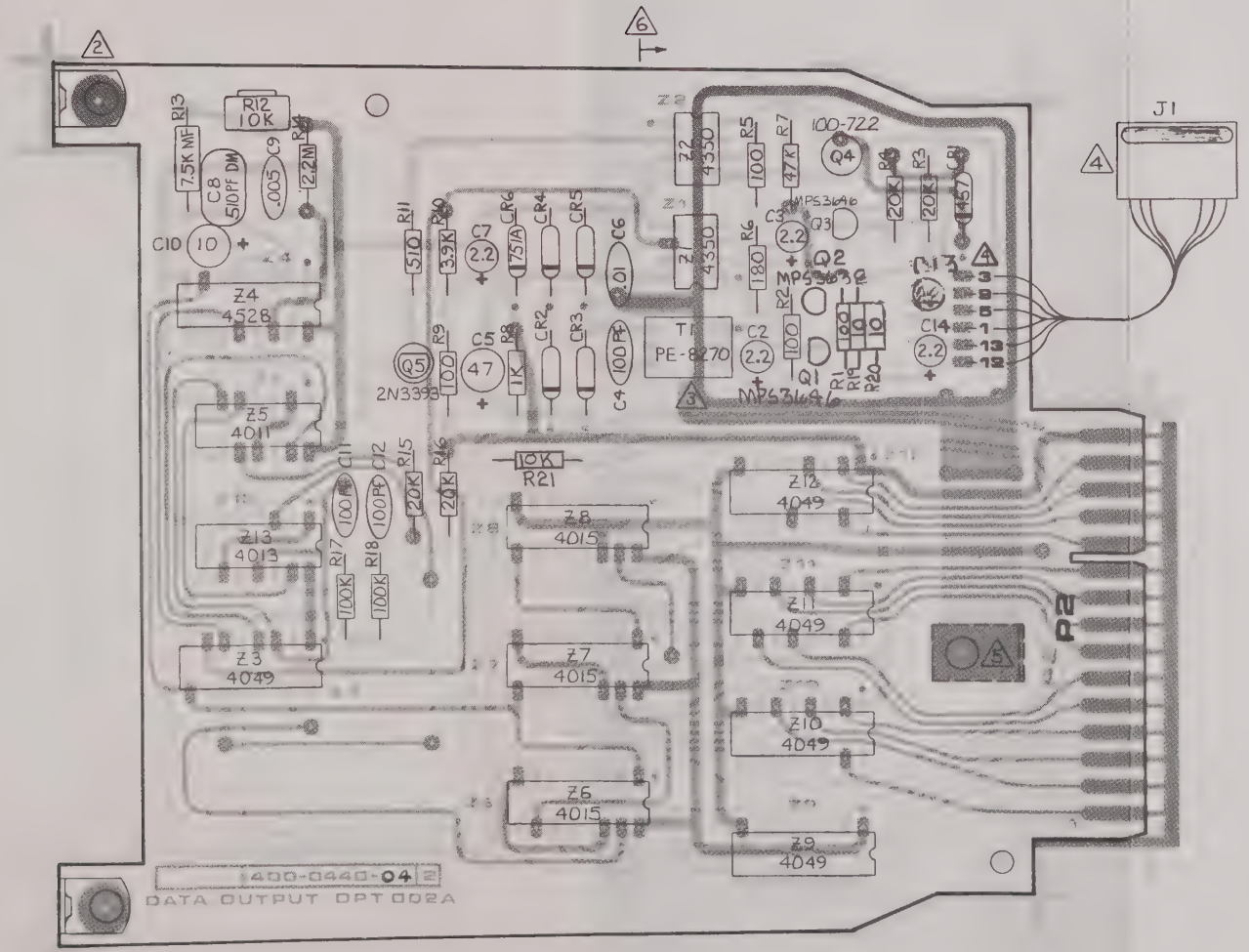

*SWITCH ERROR INDICATOR*
*SCHEMATIC 400-6420-00*



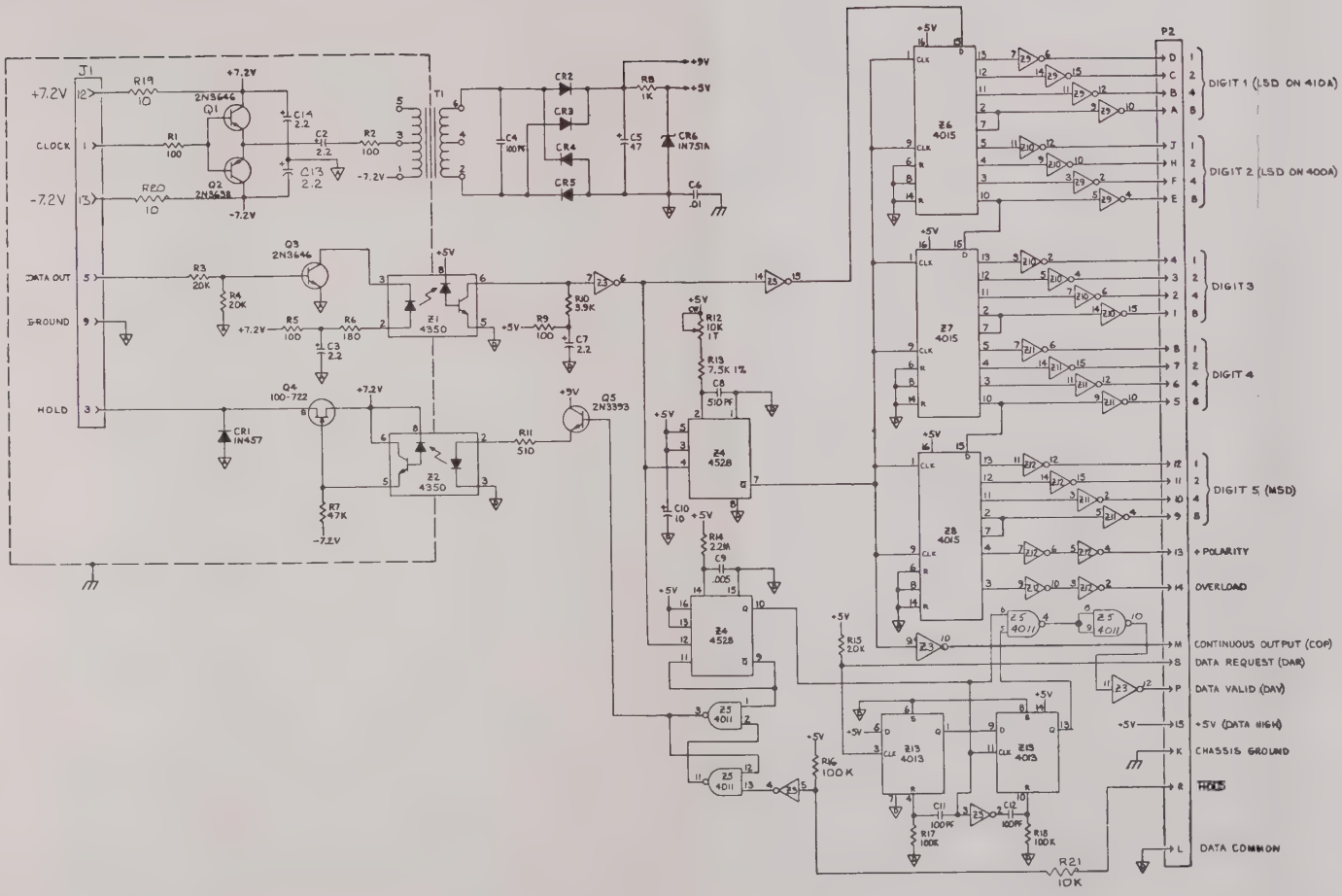

*SWITCH BOARD*
*ASSEMBLY 400-4430-00*



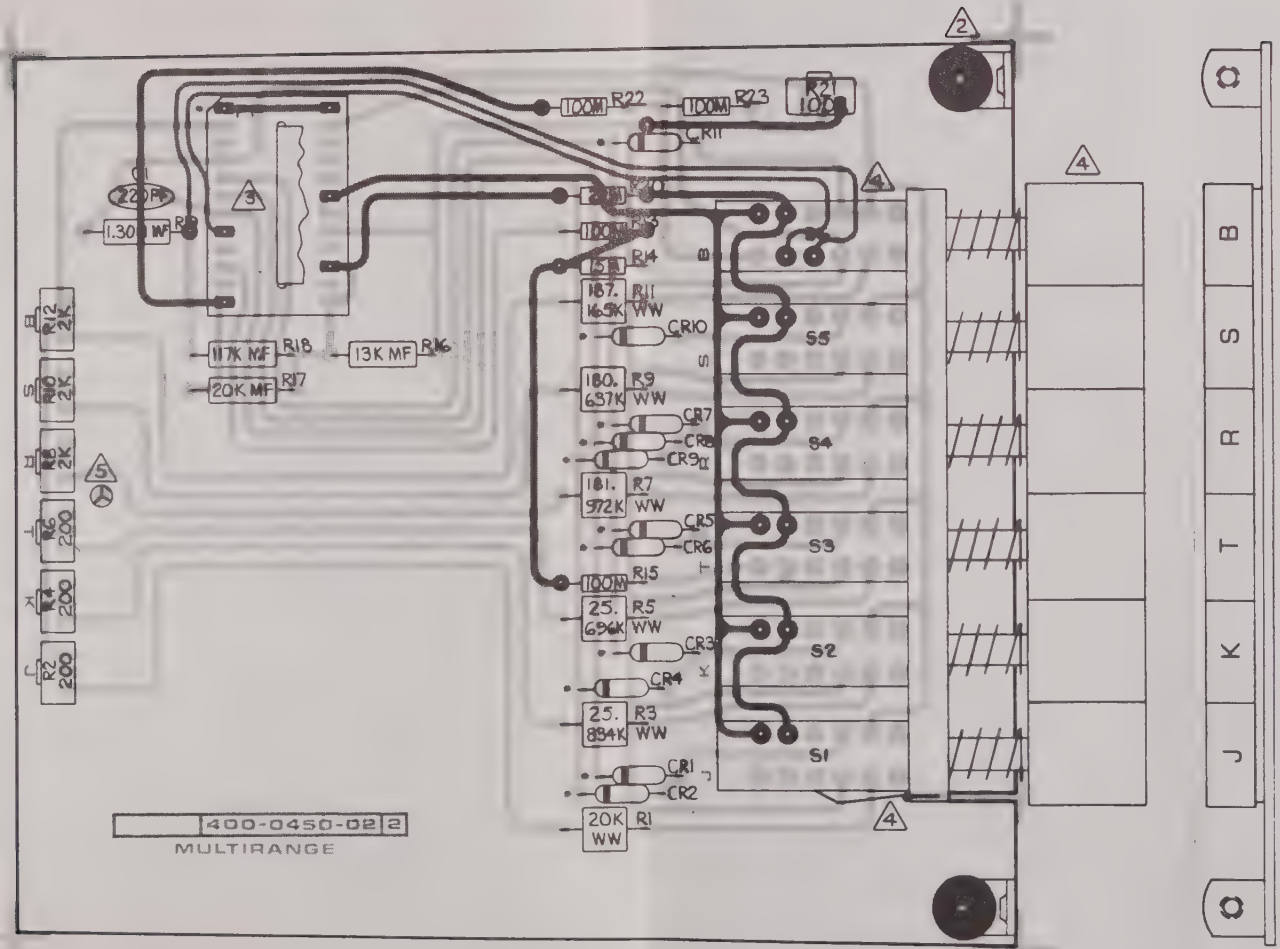

*SWITCH BOARD*
*SCHEMATIC 400-6430-00*



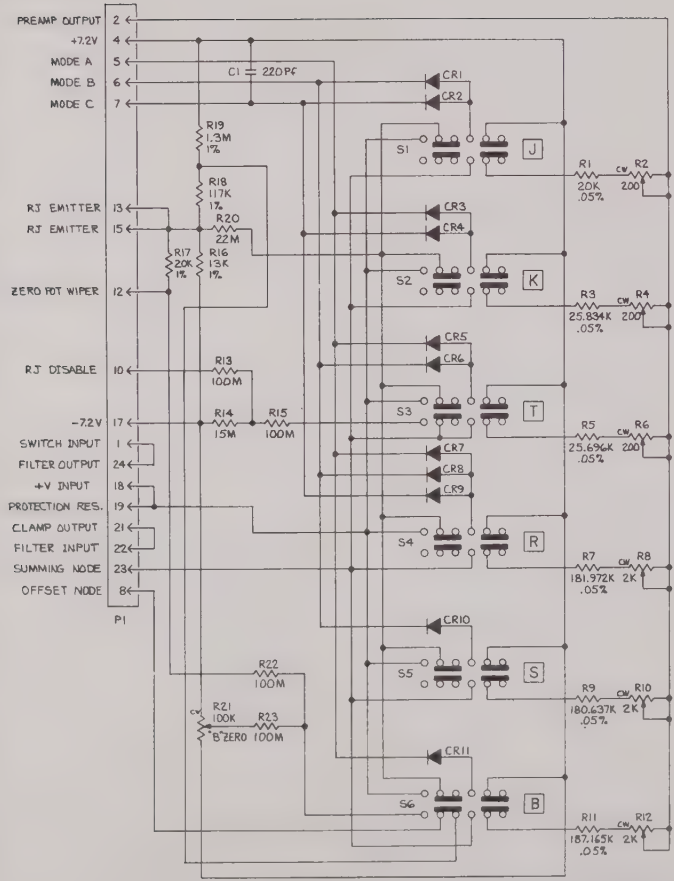

*BCD DATA OUTPUT BOARD*
*ASSEMBLY 400-4440-04*



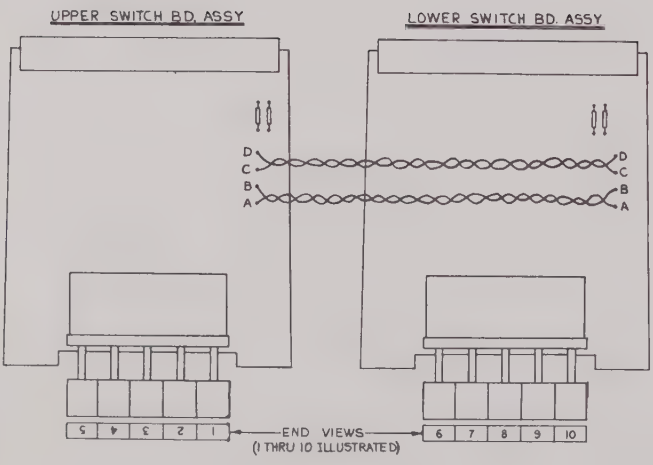

*BCD DATA OUTPUT BOARD*
*SCHEMATIC 400-6440-04*



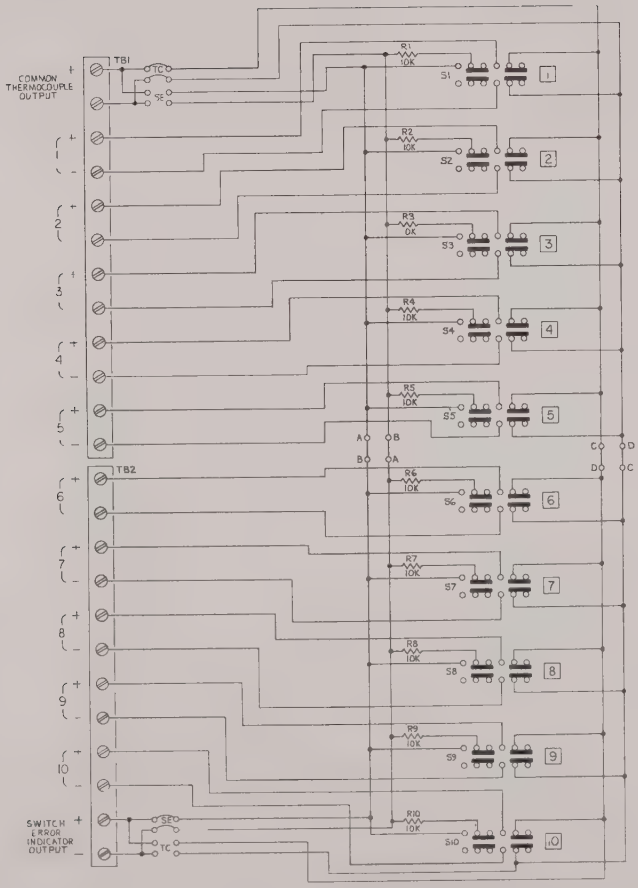

*MULTIRANGE BOARD*
*ASSEMBLY 400-4450-01*



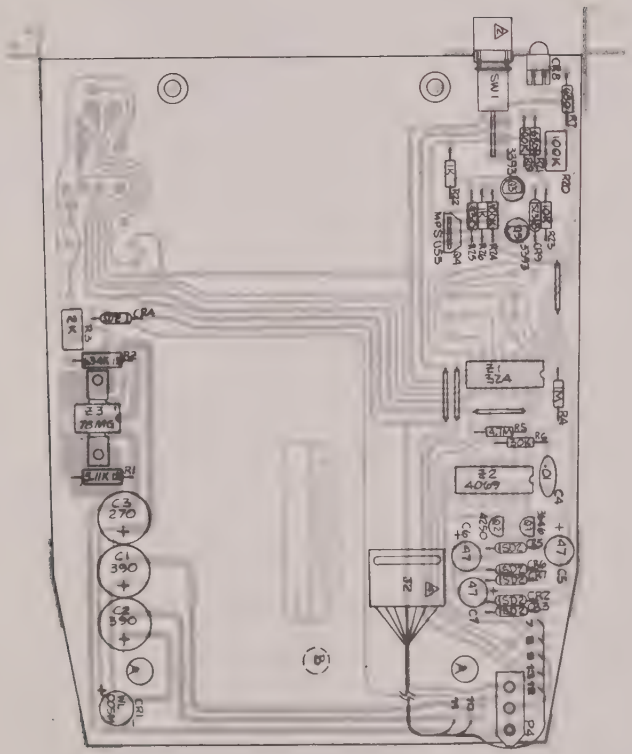

*MULTIRANGE BOARD*
*SCHEMATIC 400-6450-01*



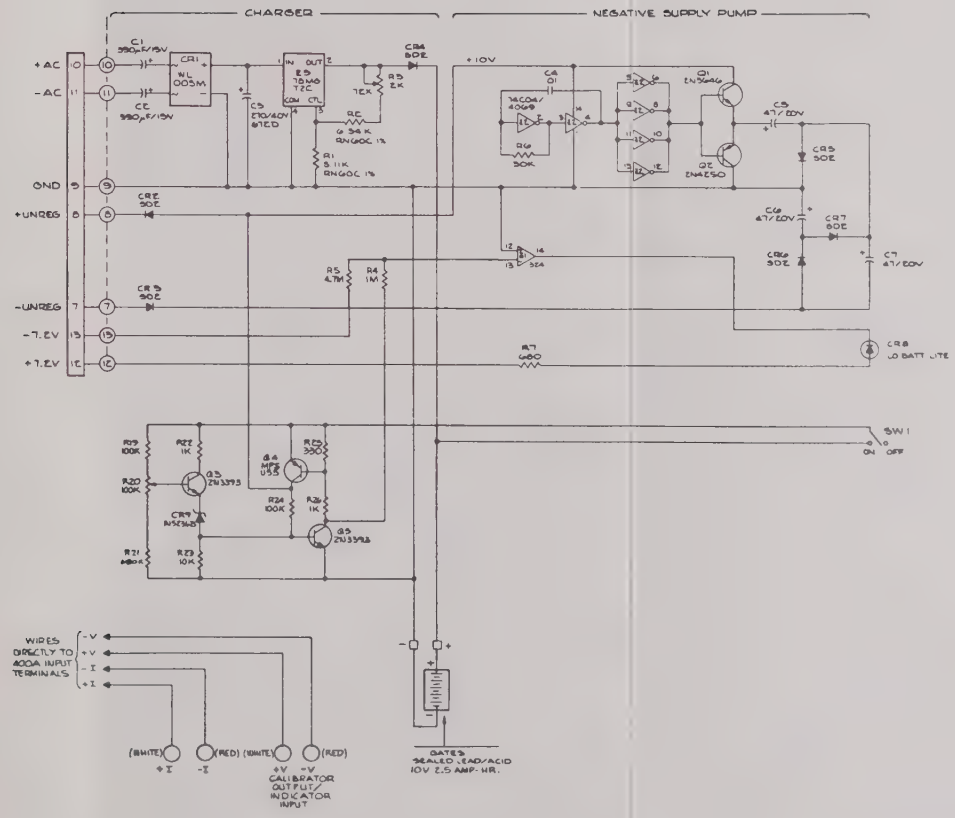

*EXTERNAL SWITCHING UNIT*
*ASSEMBLY 400-4580-01*



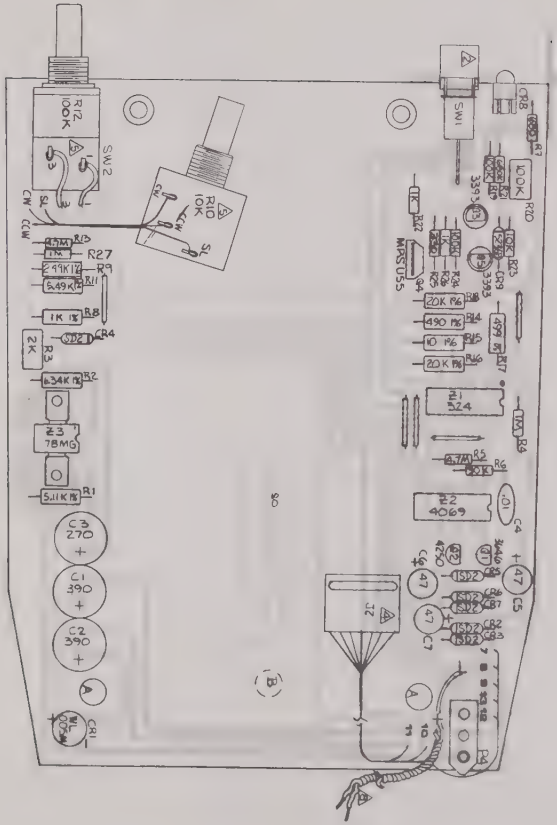

*EXTERNAL SWITCHING UNIT*
*SCHEMATIC 400-6580-00*




*POWER PACK*
*ASSEMBLY 406-4200-04*




*POWER PACK*
*SCHEMATIC 406-6200-04*


R12
10K
SW2
CW
CCW
R10
10K
SW1
R27
R11
R8
R4
R3
2K
R2
R1
C3
270
C1
390
C2
390
C4
C5
C6
C7
J2
R9
R7
R6
R5
C8
C9
C10
C11
C12
C13
C14
C15
C16
C17
C18
R13
R14
R15
R16
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R49
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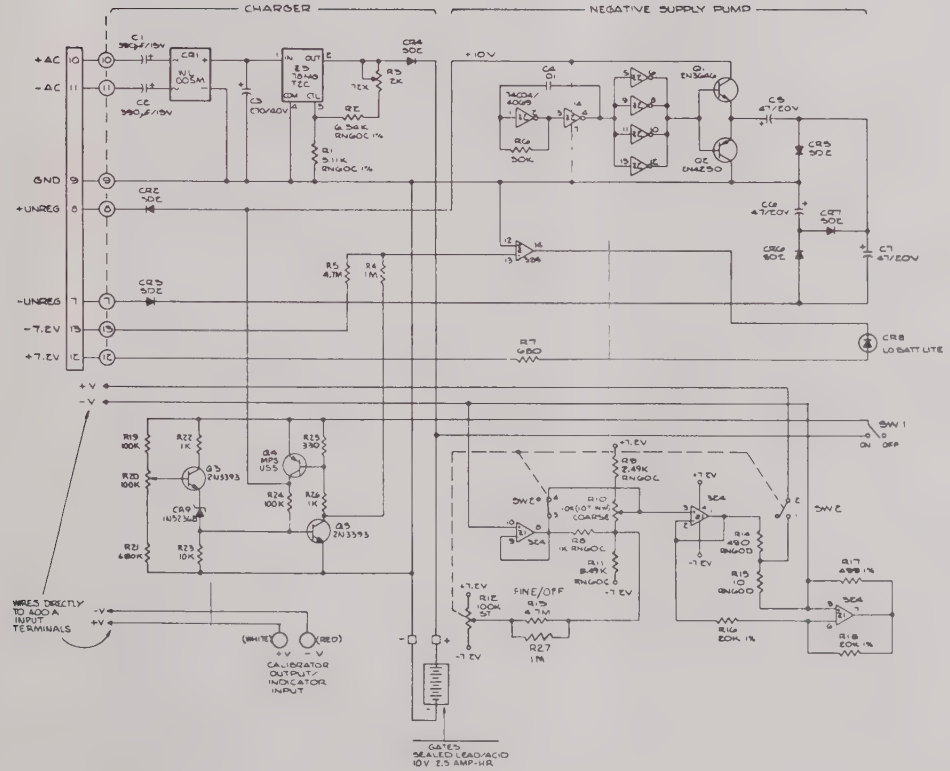
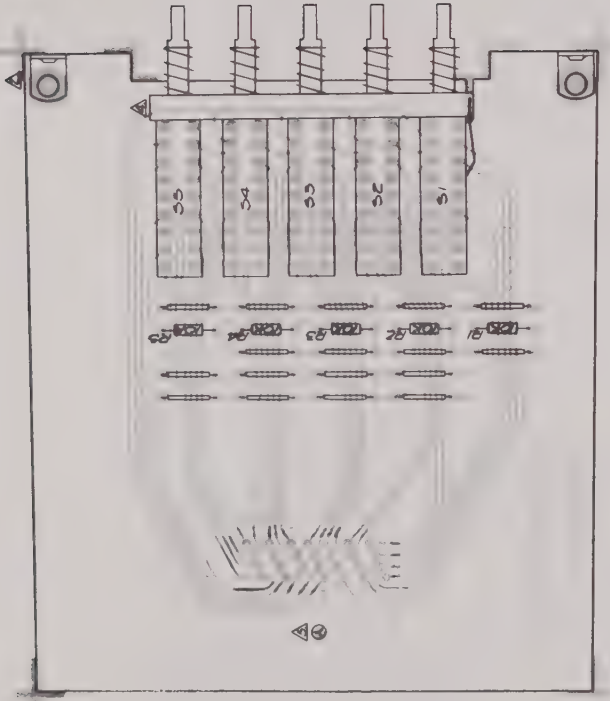
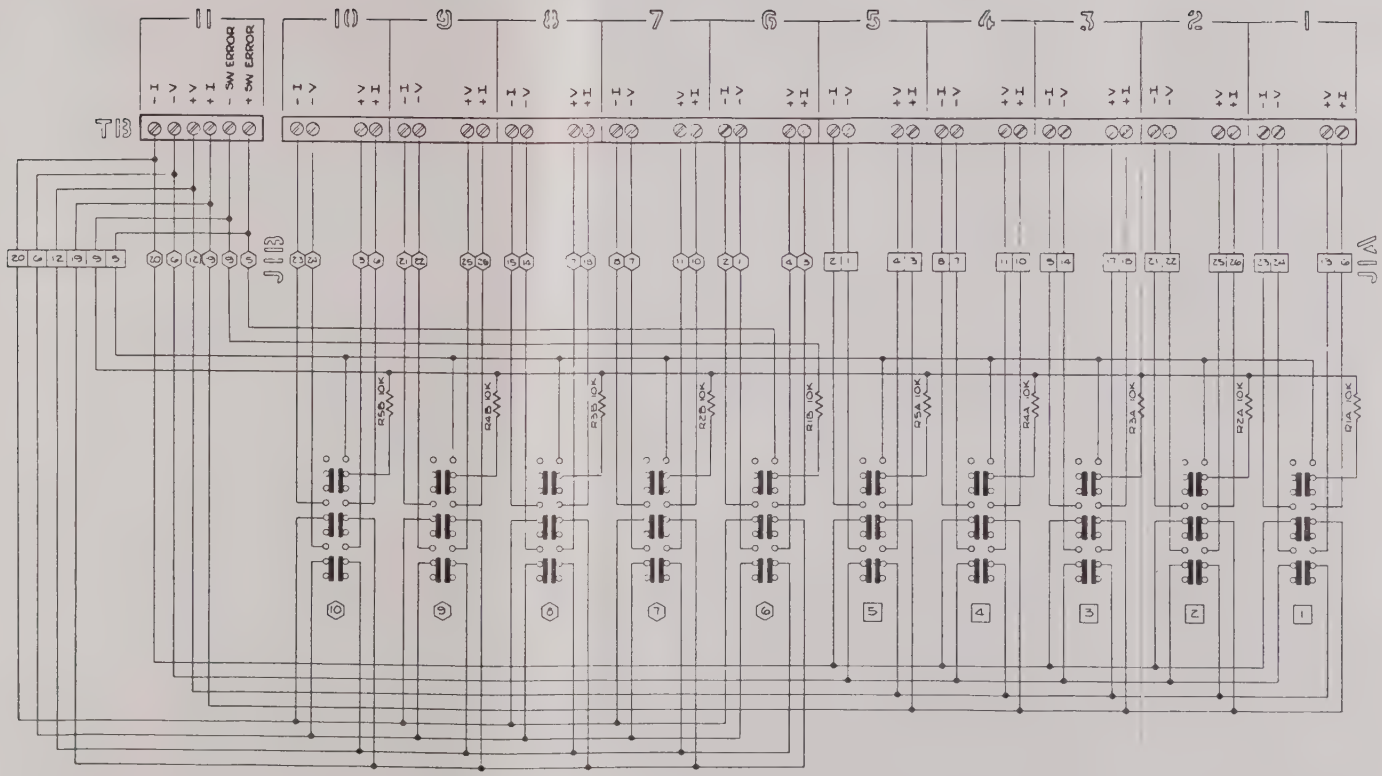
R51
R52




*POWER PACK POTENTIOMETER SCHEMATIC 407-6100-03*

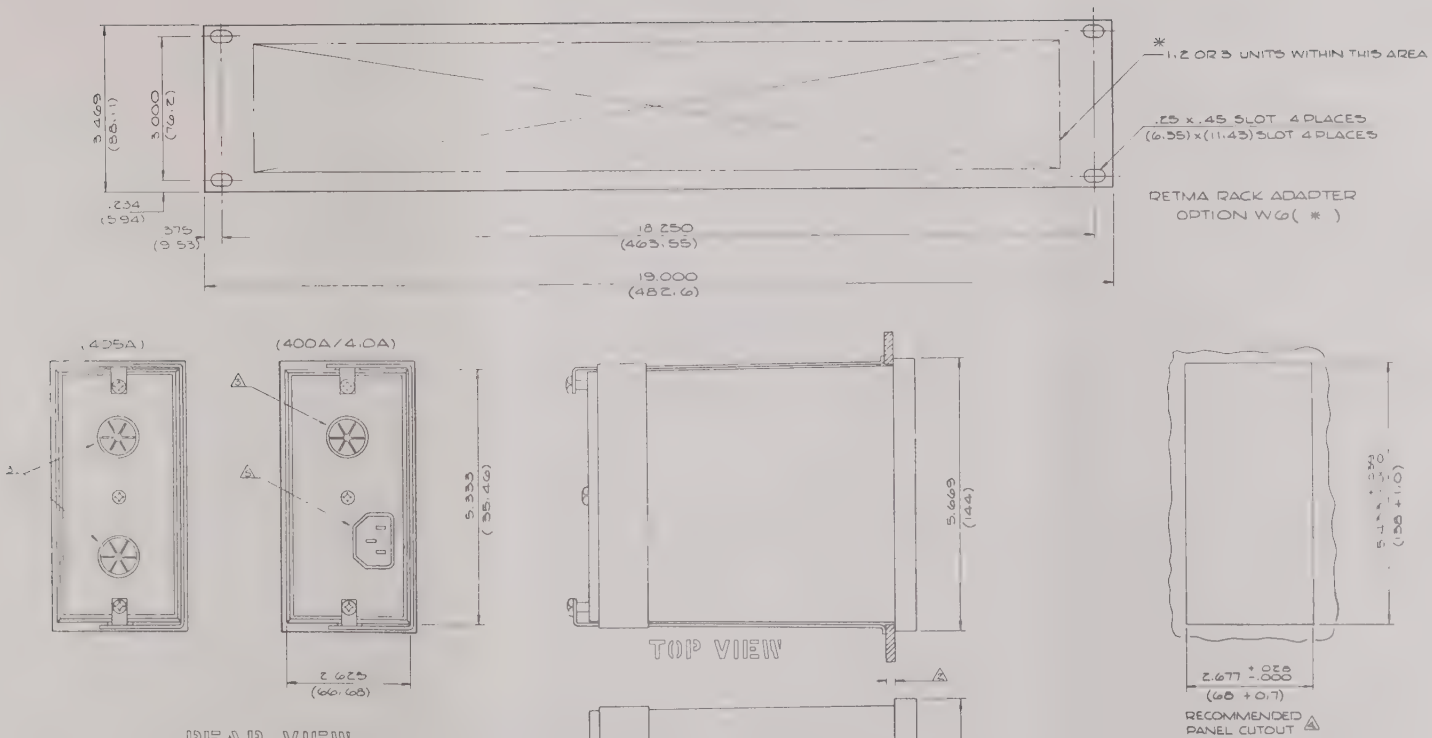


*RTD SWITCH BOARD*
*ASSEMBLY 409-4100-00*




NOTES:
1. □ INDICATES SWITCH BOARD A
2. ○ INDICATES SWITCH BOARD B

*RTD SWITCH BOARD*
*SCHEMATIC 409-6100-00*




*OUTLINE DIMENSIONAL DRAWING 000-7840-00*

# SECTION 7

# OPTIONS.

## 7.1 GENERAL

Options that may be added to increase the versatility of 400A Trendicators are Single and Dual Digital Setpoints (Options 003A and 004A) and an Analog Output (Option 005A). This section will provide installation, operation, and maintenance data for each.

### 7.1.1 OPTION 003A/004A DESCRIPTION

Option 003A provides a single digital setpoint capability, manual or automatic reset (switch selectable), and visual (red LED) or electrical out-of-limit indication. The PC plug-in board may be installed in a Model 400A or 410A Trendicator or housed in a Model 411A chassis.

When two Option 003A boards are used in a system, a dual setpoint capability is established. One board may be used in the 400A/410A chassis and the other in a 411A chassis or both may be housed in a 411A chassis. The two boards are linked by cabling as shown in Figure 7-3.

Option 004A is the same as 003A except 004A includes a hysteresis "deadband" control for two-position or on/off operation.

Limit setpoints on both options are assigned by 4 thumbwheel switches which allow for settings from -3999 to +3999. The switch in the thousandth position sets the setpoint "off" when so desired. A fifth thumbwheel switch, adjacent to the other four, designates whether the numerical setting is the high or low limit. These thumbwheel switches are accessible through the front panel in the 411A chassis, but in the 400A/410A instrument the front panel must be removed to gain access to the switches.

### 7.1.2 SPECIFICATIONS

| | |
|---|---|
| Setpoint Range: | -3999. to +3999. (In Model 410A, setting represents the 4 most significant digits). |
| Deadband Range: | 0 to -9. |
| Relays: | Form C, 115 VAC, 500mA |
| Reset: | Manual or automatic (switch selectable) |
| Terminals: | Positive lockscrew, 14 gage max |
| Resolution: | $\pm 1^{\circ}$ C or F. |

WARNING Lethal AC power voltages may be present on barrier terminals. Exercise caution when working in this area

### 7.1.3 INSTALLATION

When Option 003A or 004A is ordered from the factory, the board is installed in the Model 400A or 410A before shipment. In the event the instrument and the setpoint board are shipped separately, this procedure suggests the method of assembly.

a. If instrument is installed, remove panel mounting bracket, then disconnect sensors, grounding wires, and power ground screw.
b. Remove the front plexiglas panel (2 screws).
c. Remove 2 screws (front of instrument) which secure display board to chassis.
d. Slide board assembly forward in chassis.
e. Turn board assembly over so that component side is up.
f. Invert setpoint output board and place over main board (component side to component side).
g. Attach setpoint board to display board with 2 screws and lockwashers included in kit as shown in Figure 7-1.

### 7.1.4 OPERATION

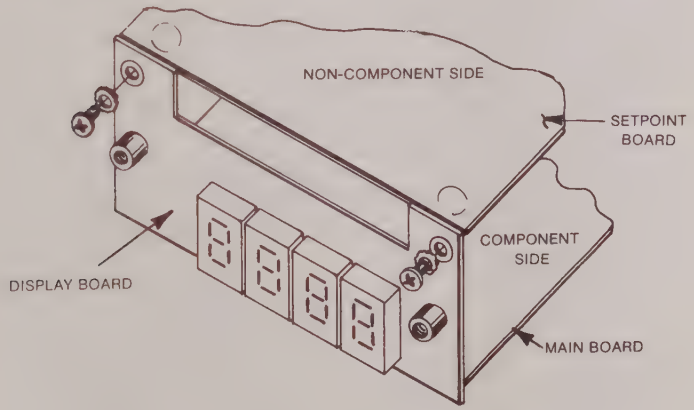



*FIGURE 7-1. INSTALLING SETPOINT BOARD ON DISPLAY BOARD*

h. Connect J1-P2 cable as shown in Figure 7-2.

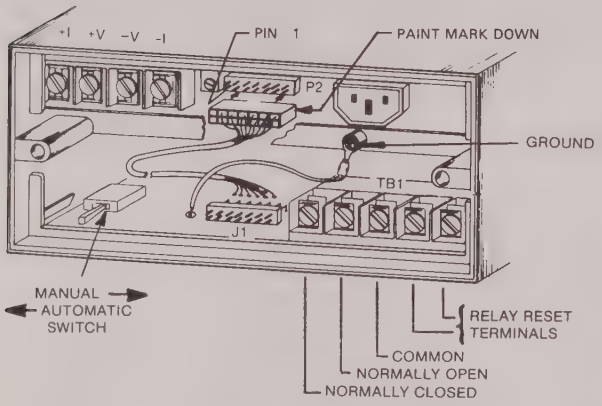



*FIGURE 7-2. REAR VIEW OF TRENDICATOR SHOWING SETPOINT BOARD INSTALLED*

i. Slide board assemblies back into chassis and re-assemble instrument, reversing steps a, b and c.

One Option 003A/004A may be installed in a 400A/410A (see Figure 7-2) or in a 411A. When two option boards are used one may be installed in each as shown in Figure 7-3 or both may be installed in the 411A. In either case a system is limited to two 003A/004A boards.

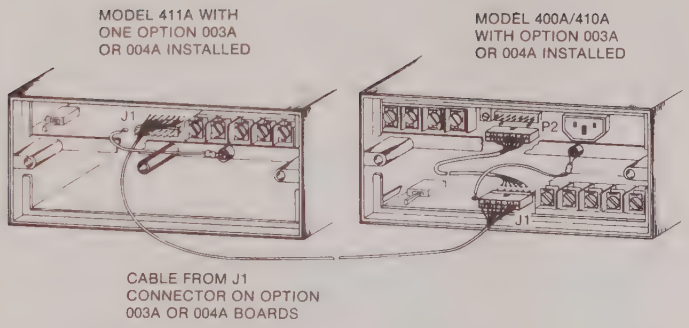



*FIGURE 7-3. CABLING DAISY-CHAINED UNITS*

### 7.1.4.1 THUMBWHEEL SWITCHES

There are 5 thumbwheel switches accessible from the front panel, shown in Figure 7-4. For reference these switches are identified as S1 and S2A through S2-D. Four of the switches, S2-A thru S2-D are used for the numerical setpoint (-3999 to +3999). Switches S2-B, S2-C and S2-D have identical wheels, providing the numbers 0 through 9 for selection. Switch S2-A gives the thousand digit as well as the polarity (+ or -) and the OFF switch. To select a setpoint, simply dial the thumbwheel switches to the desired number. The example in Figure 7-4 shows a LOW setpoint, +350. To set a negative number dial switch S2-A to -0, -1, -2 or -3 depending on the number of thousands desired. The same switch turns the setpoint OFF. Switch S1 determines whether the setpoint is HIGH or LOW. When two option boards are used one setpoint may be set LOW and the other HIGH, or both HIGH or LOW.

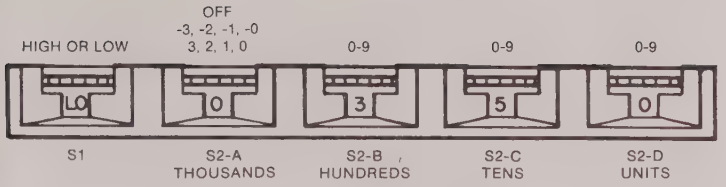



*FIGURE 7-4. THUMBWHEEL SWITCHES*

### 7.1.4.2 DEAD-BAND CONTROL

Option 004A contains a "hysteresis" or "dead-band" switch, designated as "S3". Located just behind the front panel alarm LED, the switch is adjustable for settings from 0 to minus 9. A small bladed screwdriver is recommended to turn the switch. A small notch or triangle within the screwdriver slot (shown in Figure 7-5) indicates the setting.

Example: A process requires that a limit is to be set at 100° F. Due to normal process fluctuations and noise a setpoint is required that allows for about a 6° F variation and minimizes excess operation of the contacts. The digital setpoint (thumbwheel switches) is set at 100° F. "Dead-band" (switch S3) is set at -6 (all numbers are considered minus). The process is shut-off when the digital setpoint level of 100° F is exceeded. The process will not reactivate until the temperature decreases to 94° F. "Auto manual" reset switch (S4) must be in the "auto" position for control application.

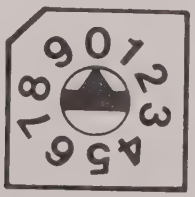



*FIGURE 7-5. HYSTERESIS SWITCH S3*

### 7.1.4.3 MANUAL/AUTOMATIC RESET COMPARATOR

All Option 003A/004A boards are equipped with a manual/automatic reset switch (S4), accessible from the rear panel. The switch, when thrown to the right, is on MAN (manual). AUTO MAN designations are etched on the board below the switch.

The options provide Form C contacts at the rear, shown in Figure 7-2. When a limit is reached, as determined by the thumbwheel switch settings, the relay closes and the LED at the front of the board lights. If the comparator is in the Automatic Reset mode the relay will open and the LED turn off when the measured variable returns to a normal condition. If the comparator is in the Manual mode the relay must be reset manually after the measured variable returns to normal. A switch closure across the relay reset terminals, shown in Figure 7-2, resets the relay.

### 7.1.5 THEORY OF OPERATION

J1 is the interconnect to P2 on the Model 400A/410A main board and is paralleled with P1 to facilitate "daisy chaining" of additional options. Pin 5 of J1, serial data out from the 400A/410A, is converted to parallel BCD data by Z1, Z4, Z5 and Z6. This parallel data (sign and magnitude) are applied to side A of BCD adder string Z7, Z8, Z9 and Z10. The least significant digit (LSD) of Side B of the adder is connected to Z19. A quad nor gate, Z19 acts like a multiplex gate, adding the BCD value of S3 (0 - 9) when appropriate (See Figure 7-6).

The output of the BCD adder (Z7, Z8, Z9, Z10) connects to Side A of the comparator chain (Z11, Z12, Z13 and Z14). Side B is connected to a second BCD adder (Z15, Z16, Z17 and Z18). Side A input to the adder is connected to switch module S1 and S2-A through S2-D, which are used to enter the desired setpoint. The B input to adder (Z15, Z16, Z17 and Z18) has the LSD connected to the output of Z20. Z20 works the same way as Z19 and applies a 0 - 9 from S3 (hysteresis switch) when logic conditions are satisfied (See Figure 7-6).

Z3, Z21 and Z22 provide a logic "1" at Z23 (pin 5) according to Figure 7-6. The clock input of Z23 is supplied by the delay one-shot (Z1 pin 9), allowing serial data to settle before updating. Z23 (pin 1) is the "set point true" signal that drives Z23 (pin 8) and Q1, Q2. These transistors, in turn, actuate K1 and illuminate CR2, indicated set point true.

In automatic reset position of S4, Z23 (pin 10) is connected to Z23 (pin 2, $\overline{Q}$) and is automatically returned to zero (Q1 and Q2 off) when the next "not out-of-limit" condition exists.

In manual mode, reset is accomplished by shorting across "remote reset" terminals. This short causes the 400kHz clock (impressed on primary of T2) to be coupled across the guard to T1 and back to the reset pin of Z23 (pin 10). In the manual mode, reset is accomplished only by remote or local actuation after process variable has returned within limits.

| HI/LO | POLARITY SETTING | ALGEBRAIC 400A/410A READING* | ALARM Z23-5 |
|---|---|---|---|
| HI | + | - or +< | 0 |
| HI | + | +> | 1 |
| LO | + | +> | 0 |
| LO | + | - or +< | 1 |
| HI | - | -< | 0 |
| HI | - | + or ->| 1 |
| LO | - | + or ->| 0 |
| LO | - | -< | 1 |

*relative to set point

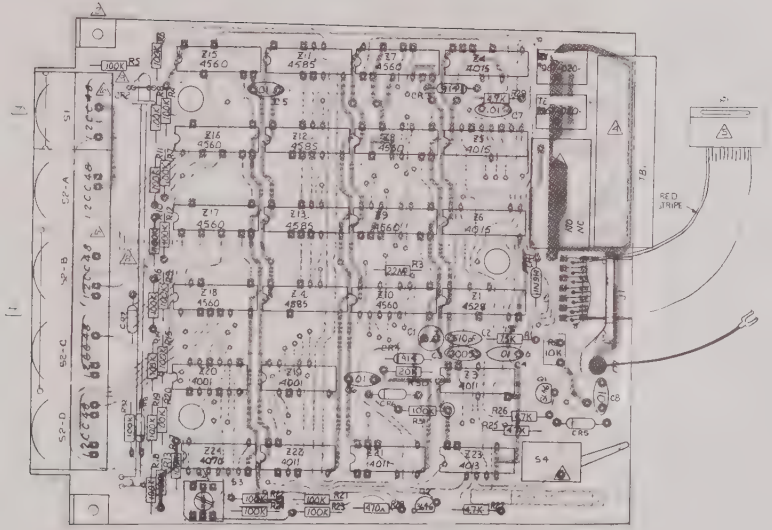
EXAMPLE: If the HI/LO limit on the thumb-wheel switch is set on "HI" and the numerical polarity setting is plus, a 400A/410A reading of any plus value greater than the thumbwheel setting places a logic "1" at Pin 5 of IC Z23.

*FIGURE 7-6. TRUTH TABLE*

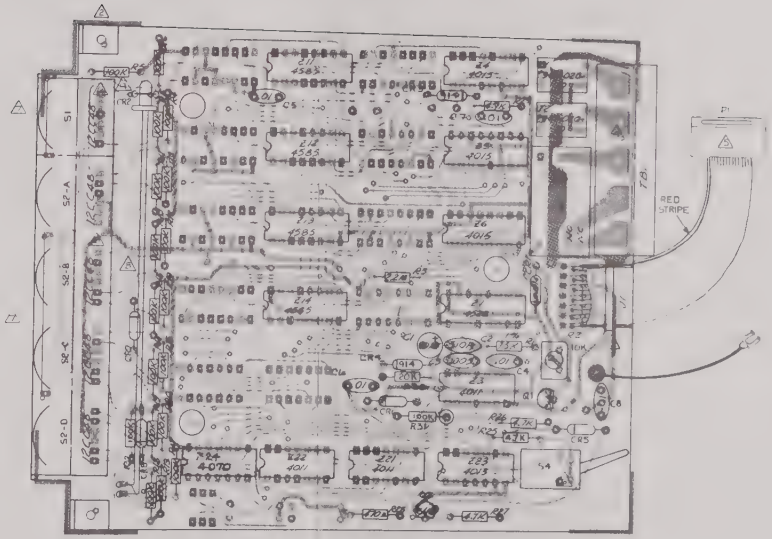
## 7.1.6 PARTS LIST

**SETPOINT BOARD (OPTIONS 003A/004A), ASSEMBLIES 400-4400/400-4401**

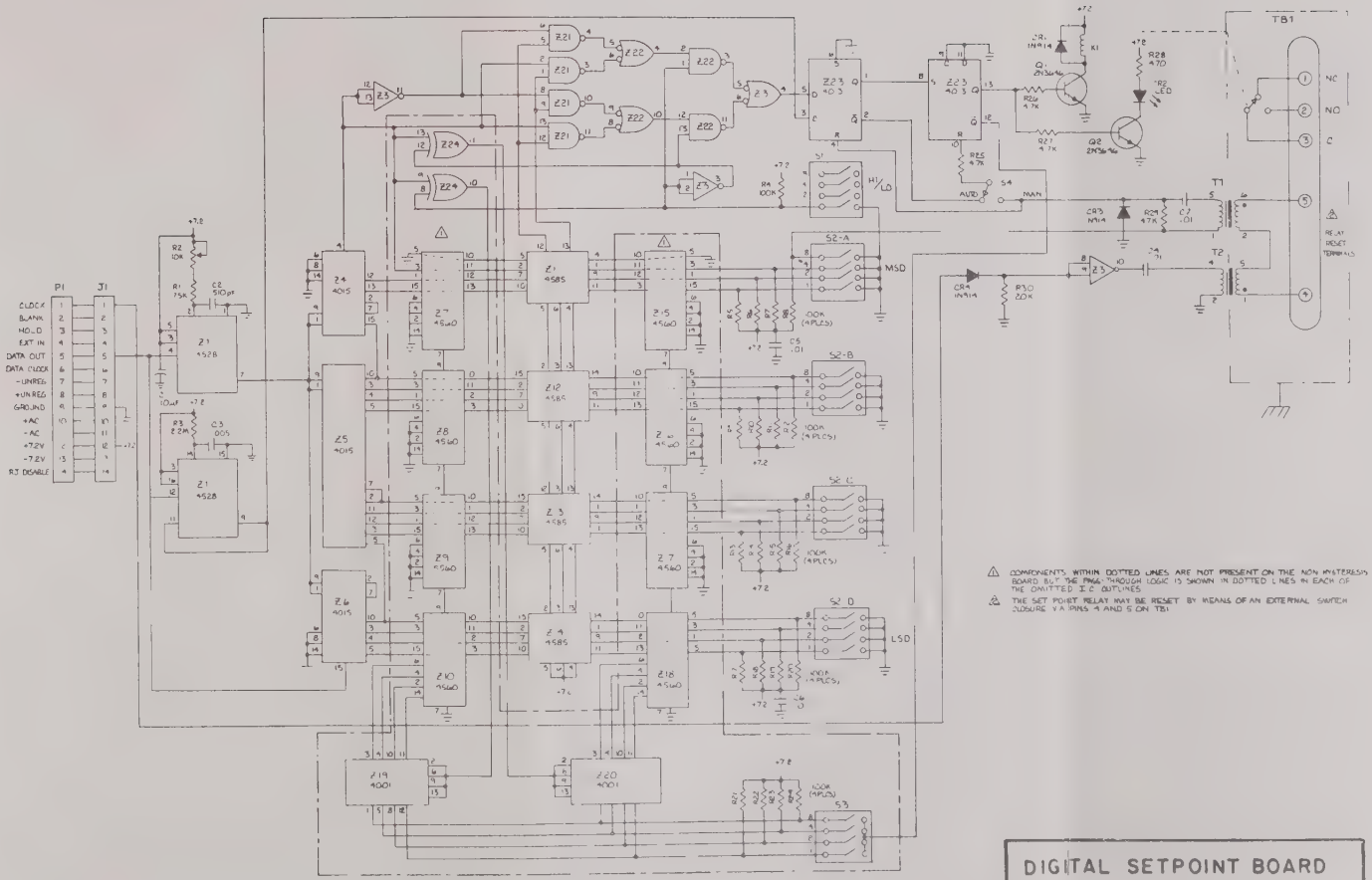
| REF DES | DESCRIPTION | QTY 003A | QTY 004A | PIN | MFR | MFR'S PIN | REC SPARES |
|---|---|---|---|---|---|---|---|
| C1 | Cap. Tant. 10 @ 35V | 1 | 1 | 916-010-35 | Sprague | 196D | |
| C2 | Cap. Mica. 510 pF | 1 | 1 | 915-035-11 | Sprague | DM15 | |
| C3 | Cap, Disc, .005 @ 1KV | 1 | 1 | 900-085-03 | Sprague | 5Ga | |
| C4—C7 | Cap, Disc, .01 @ 500V | 4 | 4 | 900-021-04 | Sprague | 5GA | |
| CR1 | Diode, 1N914 | 3 | 3 | 961-091-40 | Teledyne | 1N4148 | |
| CR2 | LED, Red | 1 | 1 | 968-010-11 | Litronix | RL-2000 | |
| CR3, CR4 | Diode, 1N914 | | | 961-091-40 | Teledyne | 1N4148 | |
| J1 | Connector, PC7M | 1 | 1 | 973-380-00 | Berg | 65625-114 | |
| K1 | Relay | 1 | 1 | 970-011-01 | Am.Zettler | Az530-09-100 | 1 |
| Q1, Q2 | Transistor, 2N3646 | 2 | 2 | 962-364-60 | Motorola | NPNSH106 | 1 |
| R1 | Resistor, 7.5K | 1 | 1 | 920-475-01 | Allen Bradley | RN60C | |
| R2 | Potentiometer, 10K | 1 | 1 | 960-011-16 | Beckman | 72XL | 1 |
| R3 | Resistor, ¼W 5% 2.2M | 1 | 1 | 942-202-25 | Allen Bradley | | |
| R4—R20 | Resistor, ¼W 5% 100K | 17 | 17 | 942-201-04 | Allen Bradley | | |
| R21—R24 | Resistor, ¼W 5% 100K | 0 | 4 | 942-201-04 | Allen Bradley | | |
| R25—R27 | Resistor, ¼W 5% 4.7K | 4 | 4 | 942-204-72 | Allen Bradley | | |
| R28 | Resistor, ¼W 5% 470 | 1 | 1 | 942-204-71 | Allen Bradley | | |
| R29 | Resistor, ¼W 5% 4.7K | | | 942-204-72 | Allen Bradley | | |
| R30 | Resistor, ¼W 5% 20K | 1 | 1 | 942-202-03 | Allen Bradley | | |
| S1 | Switch, Thumbwheel | 1 | 1 | 969-011-27 | EECO | 12769 | 1 |
| S2 | Switch, 4-wheel | 1 | 1 | 200-7020-01 | Doric | Special | 1 |
| S4 | Switch, Toggle | 1 | 1 | 969-010-73 | Singer | T8001 | 1 |
| S3 | Switch | 0 | 1 | 969-011-28 | EECO | 2300 | 1 |
| T1, T2 | Transformer | 2 | 2 | 967-020-10 | Pulse | 8270 | |
| TB1 | Terminal, 5 position | 1 | 1 | 973-010-68 | Reed | 6PCR05-002 | |
| Z1 | IC, Mono-vibrator | 1 | 1 | 965-587-14 | Fairchild | 4528 | 1 |
| Z3 | IC, 4-2 IN NAND | 3 | 3 | 965-587-02 | Motorola | 4011 | 1 |
| Z4—Z6 | IC, Dual, CMOS | 3 | 3 | 965-587-03 | Motorola | 4015 | 1 |
| Z7—Z10 | IC, BCD Adder | 0 | 8 | 965-587-63 | National | 4560 | 1 |
| Z11—Z14 | IC, Quad Comp. | 4 | 4 | 965-587-64 | | 74C85 | 1 |
| Z15—Z18 | IC, BCD Adder | | | 965-587-68 | National | 4560 | |
| Z19, Z20 | IC, 4-2IN NOR | 0 | 2 | 965-587-01 | Motorola | 4001 | 1 |
| Z21, Z22 | IC, 4-2IN NAND | | | 965-587-02 | Motorola | 4011 | |
| Z23 | IC, Dual, CMOS | 1 | 1 | 965-587-23 | Fairchild | 4013 | 1 |
| Z24 | IC, 4-Excl or CMOS | 0 | 1 | 965-587-27 | Fairchild | 4070 | 1 |
| | Connector, Cable | 1 | 1 | 973-390-00 | Berg | 65043-030 | |




SET POINT
WITH HYSTERESIS
400-4400-02




SET POINT
W/O HYSTERESIS
400-4401-02




DIGITAL SETPOINT BOARD
OPTIONS 003A/004A
SCHEMATIC 400-6400-00

## 7.2 OPTION 005A

### 7.2.1 DESCRIPTION

Option 005A is an isolated analog output plug-in PC board for use with Model 400A and 410A Trendicators. The board provides an analog output voltage proportional to the displayed data. The linearized data is completely isolated at the rear screw terminals with automatic polarity sensing for both °F and °C measurements.

### 7.2.2 SPECIFICATIONS

| | | |
|---|---|---|
| Output Accuracy | : | ± 0.25% of reading |
| Output | : | 1mV/degree F or C (isolated) |
| Load Impedance | : | 5k ohm (minimum) |

### 7.2.3 INSTALLATION

When option 005A is ordered from the factory, the board is installed in the instrument before shipment. In the event the instrument and analog output board are shipped separately, this procedure suggests the method of assembly.

a. If instrument is installed, remove panel mounting brackets; disconnect sensor, grounding wires, and power ground screw.
b. Remove the front plexiglas panel (2 screws)
c. Remove 2 screws (front of instrument) which secure display board to chassis.
d. Slide board assembly forward in chassis
e. Turn board assembly over so that component side is up
f. Invert analog output board and place over main circuit board (component side to component side).
g. Attach analog output board to display board with 2 screws as shown in Figure 7-7 (screws and lockwashers are included in the kit).
h. Connect ribbon cable joining J1 on analog output board to P2 on main board (see Figure 7-8).
i. Slide board assemblies back into chassis and re-assemble instrument, reversing steps a, b, and c.
j. Connect ground on analog output board to chassis ground as shown in Figure 7-8.

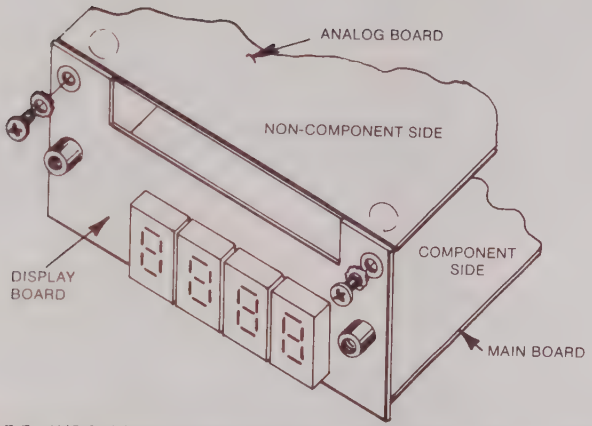



*FIGURE 7-7. INSTALLING ANALOG OUTPUT OPTION ON DISPLAY BOARD*

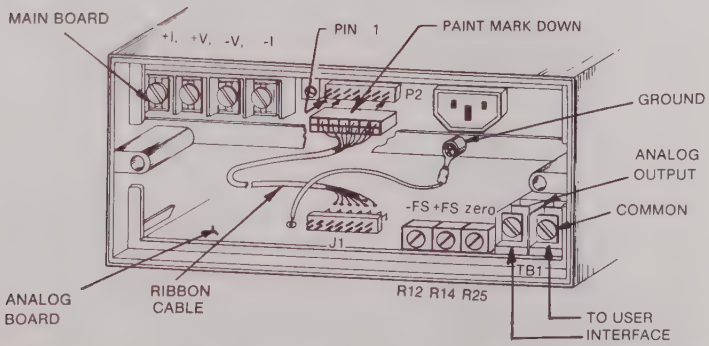



*FIGURE 7-8. REAR VIEW OF TRENDICATOR WITH OPTION 005A INSTALLED*

### 7.2.4 CALIBRATION

Figure 7-8 shows potentiometers R12 (20K -full scale adjust), R14 (20K +full scale adjust), and R25 (100K zero adjust). Each is a single-turn pot and increases resistance when turned clockwise.

Refer to Section 4 for the calibration setup. Connect a known source to the 400A/410A input terminals. Connect a DVM with 100 μV resolution to the Option 005A output terminals. Adjust R12, R14, and R25 until the analog output agrees with the Trendicator display in the following fashion:

Analog output = display count X 1 mV. (This applies to degrees, but not to tenths of degrees.)

### 7.2.5 THEORY OF OPERATION

J1 is the interconnect to P2 on the Model 400A/410A main board and is paralleled with P1 to facilitate "daisy chaining" of additional options. Pin 1 of J1 feeds a 400kHz clock signal to the inputs of three stages of hex CMOS inverter Z1. These outputs are paralleled and connected to the primary of T1 and to the inputs of the other 3 stages of Z1. The outputs of these three stages are paralleled and connected to the other side of T1 primary. This produces a 22 volt squarewave at the secondary. Spikes are filtered by C3. Diodes CR1 through CR4 form a full-wave bridge. C4 and C5 provide a filtered + 10 volts to power the analog and digital circuitry.

Transistor Q1, IC Z2, and associated components provide isolation for the coded serial BCD data from the 400A/410A. Z3 inverts and buffers the data, routing it to Z4 and Z8. Z6, Z7, and Z8 are 8-bit serial to parallel shift registers with integral output latches. The serial data is applied on Pin 2 of Z8. A shift-clock generated by Pin 7 of Z4 is applied to Pin 3 of Z6, Z7, and Z8. The output latch strobe is formed by Pin 9 of Z4 and is used to update the data after all 6 decades have been shifted into the serial-to-parallel register.

Parallel BCD data are applied to comparators Z11 through Z14. The other side of these comparators is connected to the BCD counters Z15 through Z18. These counters form divide-by-4000 timing information which is compared with BCD data. The "greater than" (A > B) output Z11 (Pin 13) provides a pulse output with a 100 Hz repetition rate. This pulse width is proportional to the magnitude of the BCD data (see Figure 7-9). This pulse is applied to the quad-analog switch (see Figure 7-10) via Z3 and Z9 to provide drive phase.

Z5 and associated components provide a +6.4 VDC reference. The appropriate polarity reference is applied through R15 or R16 and span adjust pots R13 or R14. Z19 and associated components provide output buffering and filtering to give smooth dc out.

*FIGURE 7-9. PULSE WIDTH/BCD DATA MAGNITUDE*

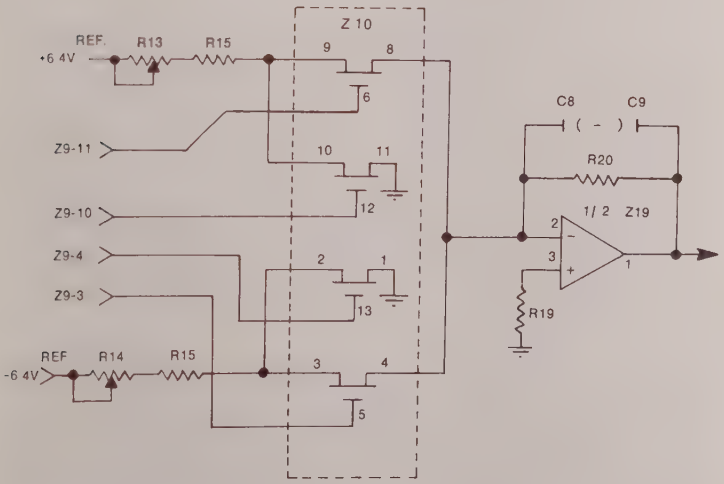
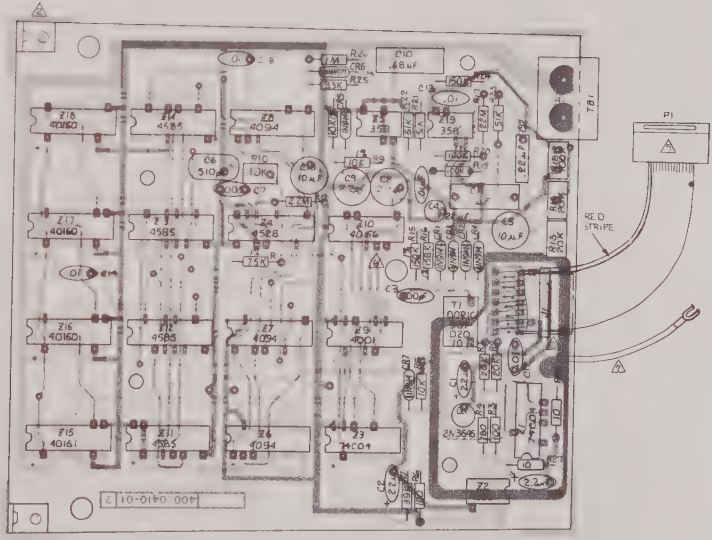



*FIGURE 7-10. QUAD-ANALOG SWITCH (Z10)*

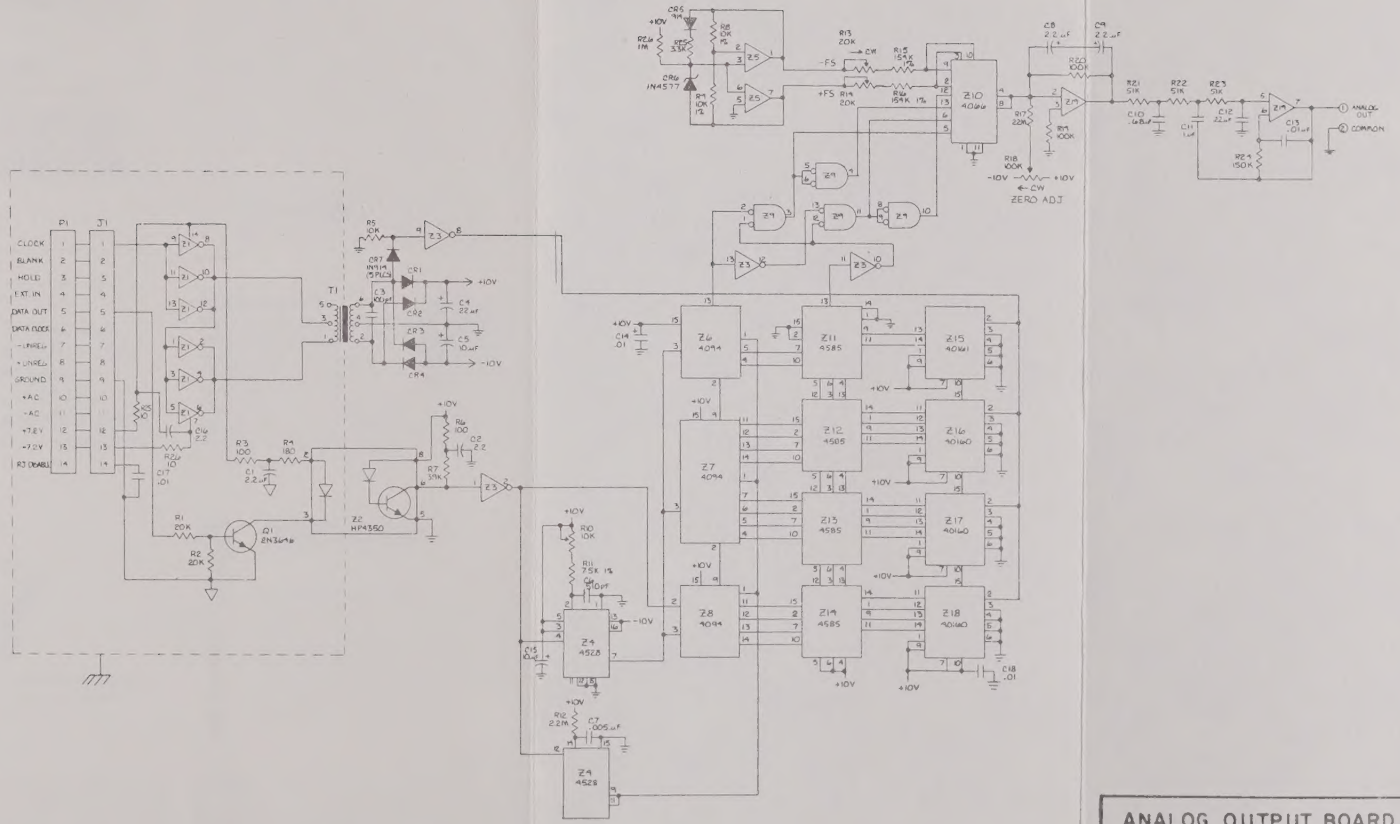
## 7.2.6 PARTS LIST

**ANALOG OUTPUT (OPTION 005A), ASSEMBLY 400-4410-XX**

| REF DES | DESCRIPTION | QTY | PIN | MFR | MFR'S PIN | REC SPARES |
|---|---|---|---|---|---|---|
| C1, C2 | Cap, Tant, 2.2 @ 35V | 5 | 916-220-04 | Sprague | 196D | |
| C3 | Cap, Disc, 100pF @ 1KV | 1 | 901-011-01 | Sprague | 5GA | |
| C4 | Cap, 22 @ 35V | 1 | 916-220-05 | Sprague | 196D | |
| C5 | Cap, Tant, 10 @ 35V | 2 | 916-010-35 | Sprague | 196D | |
| C6 | Cap, Mica, 510pF | 1 | 915-035-11 | Sprague | DM15 | |
| C7 | Cap, Disc .005 @ 1KV | 1 | 900-085-03 | Sprague | 5GA | |
| C8, C9 | Cap, Tant, 2.2 @ 35V | | 916-220-04 | Sprague | 196D | |
| C10 | Cap, .68mF Film | 1 | 919-068-00 | Plessy | | |
| C11 | Cap, 1mF Film | 1 | 919-100-00 | Plessy | | |
| C12 | Cap, .22mF Film | 1 | 919-022-00 | Plessy | | |
| C13, C14 | Cap, Disc, .01 @ 500V | 3 | 900-021-04 | Sprague | 5GA | |
| C15 | Cap, Tant, 10 @ 35V | | 916-010-35 | Sprague | 196D | |
| C16 | Cap, Tant, 2.2 @ 35V | | 916-220-04 | Sprague | 196D | |
| C17 | Cap, Disc, .01 @ 500V | | 900-021-04 | Sprague | 5GA | |
| CR1-CR5 | Diode, 1N914 | 6 | 961-091-40 | Teledyne | 1N4148 | |
| CR6 | Diode, 6.4V | 1 | 961-457-70 | Siements | 1N4577 | |
| CR7 | Diode, 1N914 | | 961-091-40 | Teledyne | 1N4148 | |
| J1 | Connector, PC7M | 1 | 973-380-00 | Berg | 65625-114 | |
| Q1 | Transistor, 2N3646 | 1 | 962-364-60 | Motorola | NPNSH106 | 1 |
| R1, R2 | Resistor, ¼W 5% 20K | 2 | 942-202-03 | Allen Bradley | | |
| R3 | Resistor, ¼W 5% 100 | 2 | 942-201-01 | Allen Bradley | | |
| R4 | Resistor, ¼W 5% 180 | 1 | 942-201-81 | Allen Bradley | | |
| R5 | Resistor, ¼W 5% 10K | 1 | 942-201-03 | Allen Bradley | | |
| R6 | Resistor, ¼W 5% 100 | 1 | 942-201-01 | Allen Bradley | | |
| R7 | Resistor, ¼W 5% 3.9K | 1 | 942-203-92 | Allen Bradley | | |
| R8, R9 | Resistor, RN60C, 10K | 2 | 920-410-02 | Allen Bradley | | |
| R10 | Pot, 10K Cermet | 1 | 960-011-16 | Beckman | 72XL | 1 |
| R11 | Resistor, 1% 7.5K | 1 | 920-475-01 | Allen Bradley | RN60C | |
| R12 | Resistor, ¼W 5% 2.2M | 1 | 942-202-25 | Allen Bradley | | |
| R13, R14 | Pot, 20K Cermet | 2 | 960-012-11 | Beckman | 72XL | 1 |
| R15, R16 | Resistor, 1% 154K | 2 | 920-415-43 | Allen Bradley | RN60C | |
| R17 | Resistor, ¼W 5% 22M | 1 | 942-202-26 | Allen Bradley | | |
| R18 | Resistor, 100K Cermet | 1 | 960-011-18 | Beckman | 72XL | 1 |
| R19 | Resistor, ¼W 5% 100K | 1 | 942-201-04 | Allen Bradley | | |
| R20 | Resistor, 1% 100K | 1 | 920-410-03 | Allen Bradley | RN60C | |
| R21-R23 | Resistor, ¼W 5% 51K | 3 | 942-205-13 | Allen Bradley | | |
| R24 | Resistor, ¼W 5% 150K | 1 | 942-201-54 | Allen Bradley | | |
| R25 | Resistor, ¼W 5% 3.3K | 1 | 942-203-32 | Allen Bradley | | |
| R26, R27 | Resistor, ¼W 5% 10 | 2 | 942-201-00 | Allen Bradley | | |
| T1 | Transformer | 1 | 967-020-10 | Pulse | 8270 | 1 |
| TB1 | Terminal Strip | 1 | 973-010-32 | Reed | 6PCR02-002 | |
| Z1 | IC, Hex Inverter 74C04 | 2 | 965-587-05 | RCA | 4069 | 1 |
| Z2 | IC, Optical Isolator | 1 | 965-570-00 | HP | 5082-4350 | 1 |
| Z3 | IC, Hex Inverter 74C04 | | 965-587-05 | RCA | 4069 | |
| Z4 | IC, Mono-vibrator | 1 | 965-587-14 | Fairchild | 4528 | 1 |
| Z5 | IC, Dual Op Amp. | 2 | 965-617-00 | National | LM358 | 1 |
| Z6-Z8 | IC, 8-bit Register | 3 | 965-587-65 | RCA | 4094 | 1 |
| Z9 | IC, 4-2 In NOR CMOS | 1 | 965-587-01 | Motorola | 4001 | 1 |
| Z10 | IC, Quad Mux CMOS | 1 | 965-587-06 | RCA | 4066 | 1 |
| Z11-Z14 | IC, Quad Comparator | 4 | 965-587-64 | RCA | 74C85 | 1 |
| Z15 | IC, Binary Counter | 1 | 965-587-66 | RCA | 74C161 | 1 |
| Z16-Z18 | IC, BCD Counter | 3 | 965-587-67 | RCA | 74C160 | 1 |
| Z19 | IC, Dual Op. Amp. | | 965-617-00 | National | LM358 | |
| | Connector, Cable | 1 | 973-390-00 | Berg | 65043-030 | |



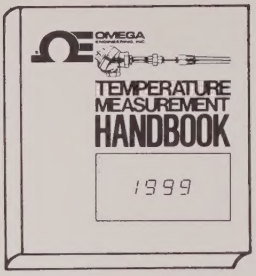

ANALOG OUTPUT
400-4410-02




ANALOG OUTPUT BOARD
OPTION 005A
SCHEMATIC 400-6410-00

# OMEGA ENGINEERING, INC.

P.O. Box 4047
Stamford,
Connecticut 06907

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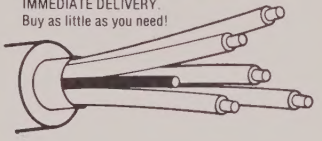
Omega Engineering is the world's leader in Temperature Measurement. If you cannot find what you need in our new Comprehensive Temperature Measurement Handbook, which lists our 7,500 temperature measurement items, please write Omega Engineering with your specific problems and let us have a hand at trying to help you — no obligation, of course.

## THERMOCOUPLE WIRE

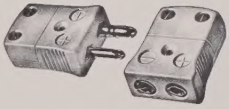
OMEGA's broad range of thermocouple wire encompasses just about every conceivable type available, including bare wire, teflon coated wire, metal-sheathed wire, all types of asbestos, glass, plastic covered and enameled wire in sizes from 0.0005" diameter on up. Even tungsten-rheniums platinum and base metal alloys, plus various extension wire types . . . all ON HAND for IMMEDIATE DELIVERY.
Buy as little as you need!



## ACCESSORIES

If it's a thermocouple accessory . . . OMEGA has it! Too many to list here, they include thermocouple insulators, protection tubes, compression fittings, color-coded connectors, high temperature ceramic connectors and jack panels, selector switches, thermocouple alloy lugs, connector heads, heavy duty miniature quick disconnects and many more.

## THERMOCOUPLE CONNECTORS

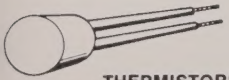


OMEGA manufactures the broadest range of color-coded Thermocouple Connectors, including Miniature, Standard, Heavy Duty and Ceramic. Fully compensated! Latest design! Off the shelf delivery.

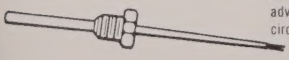
## THERMOCOUPLES AND ASSEMBLIES

OMEGA produces a broad range of probes and assemblies, a full line of sub-miniature probes, quick-disconnect type assemblies, replacement probes and thermocouple assemblies, with a variety of heads and terminations. All are available for IMMEDIATE DELIVERY.

## THERMISTORS AND RTD'S



### THERMISTORS

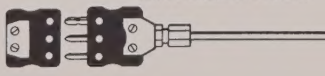


OMEGA's expanded line of curve matched thermistors and probes is available in a variety of configurations. Ask for the FREE comprehensive OMEGA review of "Thermistor Principles", plus the Glossary of Terms and Thermistor Selection Guide with design advice on creating your own circuits. IMMEDIATE DELIVERY.

## RTD's

**PLATINUM RESISTANCE THERMOMETERS**

Offering a variety of lead configurations and sizes, with compression fittings, and a choice of compression heads and quick disconnects, the OMEGA line of platinum resistance thermometers is available for IMMEDIATE DELIVERY.



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